RESISTANCE OF THE AIR

TO THE

MOTION OF PROJECTILES.

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A REVISED ACCOUNT

OF

THE EXPERIMENTS MADE WITH

THE BASHFORTH CHRONOGRAPH,

TO FIND

THE RESISTANCE OF THE AIR

TO THE

MOTION OF PROJECTILES,

WITH THE

APPLICATION OF THE RESULTS TO THE

CALCULATION OF TRAJECTORIES

ACCORDING TO

J. BERNOULLI'S METHOD.

BY

FRANCIS BASHFORTH, B.D.

LATE PROFESSOR OF APPLIED MATHEMATICS TO THE ADVANCED CLASS OF R.A. OFFICERS, WOOLWICH; AND FORMERLY FELLOW OF ST JOHN'S COLLEGE, CAMBRIDGE.

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PREFACE.

WHEN my previous work on the Motion of Projectiles was published in 1873 the correct law of resistance of the air had been determined only for velocities between 900 and 1700 feet per second. The extensive experiments made at Shoeburyness in 1878, 1879 and 1880 with ogival-headed projectiles completed the law of resistance for velocities between 100 and 2800 feet per second, but it was not found possible to assign any simple expression for the law of resistance in terms of the velocity. The Newtonian and cubic laws may however be used, excepting perhaps a brief interval just below the velocity of sound.

The generous recognition of the practical value of my labours by the Marquis of Hartington, when Secretary of State for War in 1885, induced me to attempt to complete my labours by the calculation of tables of integrals for a resistance varying as the *square* of the velocity. So far as seemed necessary similar tables for the *cubic* law of resistance have been reprinted from my former work on the same subject.

The results of my experiments have been extensively used in government treatises on Ballistics since 1877 (114). Also Captain Ingalls has given an extended and careful explanation of my results and method of experimenting in his Text-Book on *Exterior Ballistics* prepared for the use of officers under instruction at the United States Artillery School, 1886. And

Major Wuich, Professor der Artillerielehre am k. k. höheren Artilleriekurse, Wien, has abridged my tables and presented them in a new form in his *Aeussere Ballistik,* 1886.

In order to furnish the reader with full information respecting the foundation on which my work rests, I have carefully revised all my original observations and given full particulars of the results finally adopted. This re-examination of every round has introduced trifling changes in the coefficients of resistance for both spherical and ogival-headed projectiles. I have therefore taken the trouble to recalculate my General Tables for both forms of projectile, in order to render my work consistent throughout. The whole has been adapted to the use of French as well as English measures.

The close agreement between calculated and experimental ranges and times of flight for high muzzle velocities and low elevations shows that my coefficients are well adapted for the best guns of the present day. But when projectiles are fired with high muzzle velocities at high elevations, the calculated ranges and times of flight are both generally less than those given in the range tables. This discrepancy, I have no doubt, is caused in a great measure by the vertical drift of the elongated projectile, which causes an increase of range and time of flight. In fact the explanation of lateral drift given by Magnus and others also accounts for a vertical drift which is really the origin of all drift.

Recently some rounds have been fired from a wire gun at high elevations with a very high muzzle velocity, commonly spoken of as the Jubilee Rounds. But it unfortunately happened that the wind was more or less favourable to a long range in these experiments. And a moderate steady wind at the surface of the earth would become a very violent wind at a height of two or three miles, which would produce a marked effect on the motion of an elongated projectile exposed to its action for 50 or 60 seconds. I have calculated a complete range table for the case where there is no wind to disturb the motion of the projectile.

The statements and proceedings of some foreign writers on ballistics have rendered it incumbent on me to enter at some length into the history and progress of my work during the last twenty-six years. But I have confined these remarks chiefly to the conclusion of my work, so that the reader need not trouble himself unless he feels an interest in the matter.

In calculating trajectories it has of late become a common practice to reduce my coefficients, either arbitrarily, or so as to bring them into accord with those of Krupp. But I have not been able to find any satisfactory experimental authority for Krupp's tables issued in 1881. Certainly in the following year an "Annexe" (177), consisting of 37 rounds, was put forward to support a foregone conclusion, but these experiments from their nature were not to be depended upon (177), and in no single case was the time of flight recorded. The specimen of the experiments made to determine the resistance of the air for velocities higher than 700 m.s. (181) ought to establish the character of Meppen for ballistic experiments. In all cases the Krupp party were careful to follow and not to lead. An inspection of diagram (178) will show how carefully they followed my law of resistance, merely reducing my coefficients, as is shown by line 3 compared with line 1 or 2.

In 1872 Mayevski combined my results published in 1868 with a few of his own experiments, from which he professed to have obtained "résultats *russes* et anglais," which however coincided with my previously published results (169). Consequently, so far as Mayevski's experiments had any value, they entirely supported my previous conclusions.

The method of calculating trajectories published by Siacci requires all the three tables previously used by Niven for that purpose. Ingalls (173) has pointed out a grave defect in that Siacci has not found an analytical expression for a most important quantity, α or $\sec\overline{\phi}$, but has merely given the empirical rule $\sec\overline{\phi} = (\sec\phi)^{\frac{n-2}{n-1}}$. Turning to Niven's paper it will be found that the two values of this quantity required for distance and for time have been carefully determined, and still more so in a paper

On certain Approximate Formulae for calculating the Trajectories of Shot, by Professor Adams (*Nature*, Jan. 16, 1890). It must be plain that arbitrary coefficients of resistance, and empirical quantities are quite inadmissible in any calculations made to test the results of careful experiment. Krupp, Mayevski and Siacci use tables of the same kind as mine (108) and (110).

The reader will find in the following work a very full account of every round from which coefficients of resistance have been obtained by me for both spherical and ogival-headed projectiles. In consequence of the Krupp scare, special experiments were made in 1887 to test my coefficients on a long range, when they were found to be quite satisfactory. Still no notice seems to have been taken of this fact, or of Captain May's remarks (151), by calculators of trajectories.

My coefficients of resistance for low velocities have been tested (122) by calculating a Range Table for the 6·3-inch Howitzer for elevations 5° to 35° with satisfactory results.

For high velocities I have used the Range Table for the 4-inch B.L. gun. The calculated ranges and times of flight for velocities 1900 to 960 f.s., and for elevations 1° to 4° (125), are quite satisfactory; and this conclusion is confirmed by the use of the General Tables (126) and (188). In the same manner the Range Table of Captain May, R.N., has been used (123), (124) and (189) to show the accuracy of my coefficients of resistance *when the projectile moves nearly in the direction of its axis.*

I therefore claim to have accomplished in a satisfactory manner all I undertook to do, namely, to find by experiment the law of resistance to spherical projectiles and also to elongated projectiles when they move approximately in the direction of their axes.

The tables and coefficients already given are sufficient for the calculation of trajectories of spherical projectiles and of elongated projectiles where there is no sensible drift. But in attempting to calculate the trajectories of elongated projectiles fired from rifled guns with high muzzle velocities and at considerable elevations, it will be well to recognise the truth of the statement of St-Robert—that the problem taken in all its generality presents great difficulties. I have endeavoured to explain the nature of the movement of such an elongated projectile, which is supposed to be projected with perfect steadiness from a rifled gun, according to the conclusions of St-Robert. Referring to (141) it is evident that shortly after the elongated projectile leaves the gun *it must be raised up bodily* by the resistance of the air, so as to cause it to move as if it had been fired at a somewhat higher elevation than it really was. I have given the calculated ranges and times of flight for elevations of 1° to 15° for the 4-inch B.L. gun (148). As the elevation increases above 4° it appears that the calculated ranges and times of flight fall short more and more of those quantities respectively given by experiment. Suppose we reduced the coefficients of resistance so as to obtain a calculated range equal to the experimental range for an elevation of 10°, we should find, as Captain May did (151), that these coefficients would not give a correct time of flight—and they would destroy the agreement actually obtained for low elevations. The reduction of the coefficients of resistance therefore cannot be the solution of the difficulty, as is commonly supposed. Some correction is required which will increase *both* the calculated range and time of flight.

In (149) the calculated ranges of (148) are arranged in a different manner. I have found from the Range Table the elevation and time of flight corresponding to each calculated range. It is evident that the corrections for elevation at once give the correct ranges and very approximate corrections for the times of flight. These latter corrections would have been still more satisfactory if the decrease in density of the air corresponding to the height of the shot had been taken into account in the calculation of the trajectories (148). For the reason stated (146) this mode of correction will be only an approximation to the truth—but it will perhaps be found to be satisfactory. The law of the correction can only be obtained by the calculation of numerous trustworthy Range Tables, or by theoretical considerations.

I fear that the reader will meet with some repetitions in the following work, but it was impossible to avoid them entirely on account of the complicated nature of the various questions to be dealt with. Although it will not surprise me to find that what has been said produces little immediate effect, it will always be a satisfaction to me to have stated my case carefully and supported it by reference to, and specimens of, my early results and tables, in none of which have I found it necessary to introduce any important change.

The English Range Tables I have made use of appear to me surprising from their minute accuracy. I have derived much assistance from Captain Ingalls's excellent work on Exterior Ballistics, and the numerous references to that work will explain in what respect I am indebted to his labours.

Minting Vicarage,
March, 1890.

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French Measures.

CHAPTER I.

INTRODUCTION.

1. THE leading mathematicians of the last two centuries gave much attention to the subject of Ballistics. They seem to have accomplished all that was possible in such a case, in the absence of reliable experiments by which they could test their theories. Galileo made the first attempt to determine the theoretical path of a projectile acted on by gravity, but unresisted by the air, in his *Scienze Nuove*, 1638, and found it to be a parabola. Newton investigated the theoretical path of a projectile, supposing the air to offer a resistance varying as the velocity. In 1718 Keill proposed his famous challenge to Continental mathematicians, "Invenire curvam, quam projectile de-"scribit in aëre, pro simplicissima suppositione gravitatis, atque "medii densitatis uniformis, resistentiæ vero in duplicata ratione "velocitatis[1]." J. Bernoulli soon solved the problem, supposing the resistance to vary as *any power* of the velocity, but before publishing his solution, he called upon Keill to produce his own, telling him that if he did not do as he was requested, he should accept his silence "pro tacita confessione suæ imbecilitatis." As the required solution was not produced Bernoulli triumphed not over Keill only, but also over all his English friends, who might have been expected to help him if they had known how to do so. Bernoulli refers[2] to a solution received from Brook Taylor on the 6th of November, "styli veteris," under the form $(r^4 - 1 + 4nrr + 4ur^2)$. Hermann had also given a construction in his *Phoronomia*, p. 354, similar to his own.

[1] J. Bernoulli, Opera, II. 396.

[2] Ib. p. 399.

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2. Le Seur and Jacquier remark in their edition of Newton's *Principia* (Book II., Prop. X., Prob. III.), that although Newton had omitted to consider the case of a medium resisting as the *square* of the velocity, they were unwilling that the solution of such an elegant problem should be absent from their commentaries. Having given Bernoulli's solution for any power of the velocity, they remark "ex quibus manifestum sit veræ trajectoriæ "descriptionem adeò perplexam esse, ut ex illa vix quidquam ad "usus philosophicos aut mechanicos accommodatum possit deduci." That is, it was impossible to integrate the expressions arrived at. But this solution is the one employed in this as well as in my former work. Euler also adopted Bernoulli's solution, and applied it to the case where the resistance varied as the square of the velocity. In this particular case the length of the arc of the trajectory can be found by integration. Euler divided the trajectory into small arcs, and, supposing the chord to be equal to the arc in length, by summation he found the coordinates of the path. This method of calculation was pursued by Grævenitz [1] (1764), Hugh Brown[2] (1777), and Otto[3]. But Legendre introduced a much-needed correction by treating the arc of the trajectory as the arc of a circle, and projecting its *chord* upon the axes of x and y. Another method of correction proposed by Didion was to use the arc of a parabola instead of the arc of a circle[4]. Didion has given comparative examples of the use of these methods. Lambert, Tempelhof, Francois, Otto and others have made use of long series too complicated for practical use, although Otto has provided numerous auxiliary tables [5]. His other ballistic tables were only adapted for calculating the trajectories of shot fired at high elevations.

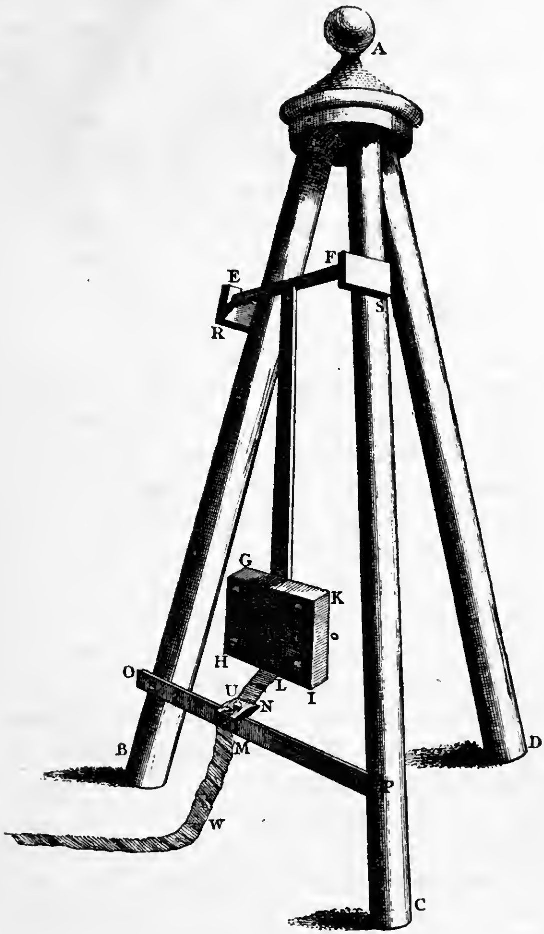
3. But there were no trustworthy means of comparing the results of theory and experiment until Robins, by the use of his ballistic pendulum and his whirling machine, made valuable attempts to discover the law of resistance of the air to the motion of small-arm bullets. He describes his ballistic pendulum as follows:—" $A\ B\ C\ D$ represents the body of the machine "composed of the three poles B, C, D, spreading at bottom, and

[1] Translated by Rieffel, 1845. [2] Translation of Euler.

[3] Tafeln für den Bombenwurf. Translated by Rieffel, as Tables de Balistiques Générales pour le tir élevé, 1845.

[4] Balistique, pp. 215, 216. [5] Neue Bal. Tafeln, 1857.

"joining together at the top *A*....On two of these poles towards "their tops are screwed on the sockets *R S*; and on these sockets



"the pendulum *E F G H I K* is hung by means of its cross piece "*E F*, which becomes its axis of suspension and on which it must "be made to vibrate with great freedom. The body of this pen-"dulum is made of iron, having a broad part at bottom which "cannot be seen in this scheme....The lower part of the pendulum "is covered with a thick piece of wood *GKIH*, which is fastened "to the iron by screws. Something lower than the bottom of "the pendulum there is a brace *O P*, joining the two poles to "which the pendulum is suspended; and to this brace there is "fasten'd a contrivance *MNU*, made with two edges of steel "bearing on each other in the line *UN*, something in the manner "of a drawing-pen....There is fasten'd to the bottom of the "pendulum a narrow ribbon *LN*[1]" which is used to measure the recoil of the pendulum. Robins published his *New Principles of Gunnery* in 1742, in which he adopted a law of resistance varying approximately as the square of the velocity, but he insisted that there was a decided change in this law at or about the velocity of sound. This position was doubted till it was confirmed by recent experiments. In reply to some adverse criticisms on his work, several papers were read and illustrative experiments were exhibited by Robins before the Royal Society. He remarked, "But as I have, for some time past, made many experiments "myself on the ranges of bullets, and have collected all that I "could meet with made by other persons; it was necessary, in "order to examine the several hypotheses of resistance, which "some of these experiments suggested, that I should be enabled "to compute the motions of resisted bodies, not only when they "were resisted in the duplicate proportion of their velocity; but "likewise when the law of resistance was varied by other rules "not hitherto supposed by any writer. And, in these investi-"gations, I had the good fortune to discover some compendious "approximations, which were as accurate, as the nature of the "subject required, and were as easy in their application, as I "could well hope for in so perplexed and intricate a matter....But "first it is necessary to examine what is the real law of resistance "of bodies moving through the air.

"I have already mentioned, that in very great changes of "velocity, the resistance *does not accurately follow the duplicate "proportion* of the velocity. But how much this variation "amounts to, and how it is adapted to the different velocities of "the resisted body; it is not easy nicely to ascertain. However, "by comparing together a great number of experiments; I am "of opinion, that till, a more accurate theory of these changes "is compleated, the two following positions may be assumed "without any remarkable error[2]."

[1] New Principles of Gunnery, p. 83.

[2] Robins's Gunnery, I. 180—183, and Hutton's ed., 180—183, 1805.

4. "*First*, that till the velocity of the projectile surpasses "that of 1100 feet in a second, the resistance may be esteemed "to be in the duplicate proportion of the velocity; and its mean "quantity may be taken to be nearly the same with that, I have "assigned in the former paper[1].

"*Second*, That if the velocity be greater than that of 11 or "1200 feet in a second, then the absolute quantity of that re- "sistance in these greater velocities will be near three times "as great, as it should be by a comparison with the smaller "velocities.—For instance, the resistance of a 12 pound shot, "moving with a velocity of 1700 feet in a second, instead of "144 lb. $\frac{1}{2}$, which I have assigned it in a former paper, will be "now three times that quantity, or 433 lb. $\frac{1}{2}$[2]." And in a note Robins remarks, that "the velocity, at which the moving body "shifts its resistance, is nearly the same, with which sound is "propagated through the air."

5. On presenting to Robins the Copley Medal in recognition of the value of his work, Mr Folkes, President of the Royal Society, observed that, "It is from these experiments, and from "those others which Mr *Robins* is still preparing to exhibit, that "we may expect to see compleated the whole, and the true theory "of projectiles. What *Galileo* and *Torricelli*, who first demon- "strated the motions of these bodies *in vacuo*, knew to be still "wanting in their theories, will hereby be supplied: and these "particulars will at last become known, which they wished that "future observers would make diligent and careful experiment "about[3]." Previously, "writers, even those of the first class" have been of opinion "that in large shot of metal, whose weight "many thousand times surpasses that of the air, and whose force "is very great, in proportion to the surface wherewith they press "thereon, this opposition is scarce discernable, and as such may, "in all computations, concerning the ranges of great and weighty "bombs be very safely neglected[4]."

The choice of "two very considerable employments" having been offered to Robins, as a reward for his labours, he accepted the office of Engineer-General to the East-India Company "as "it was suitable to his genius, and where, he believed, he should

[1] Note by Hutton, "These suppositions are not nearly correct," 181.

[2] New Principles, I. 182, Hutton's ed., pp. 180—182.

[3] New Principles, I. p. xxx.

[4] Ib. p. xxxi.

"be able to do real service, *as not being liable to be hindered* "*through the suggestions of design or ignorance, which by their* "*boasting and importunity, often insinuating themselves into the* "*direction of publick affairs, frequently render abortive the best* "*concerted schemes*[1]." The Company settled upon him £500 a year during life, on condition that he continued in their service five years. He left England for India in 1749 and died at work 1751.

6. Euler at once published a translation of Robins's *New Principles*, and illustrated the work with a lengthy commentary (1745). He also contributed a paper on the same subject to the *Memoires de l'Acad. de Berlin*, 1753, in which he showed how theoretical trajectories might be calculated according to the solution of the problem by J. Bernoulli, but only for a resistance varying as the *square* of the velocity. Both Euler's paper and his commentaries on Robins's *New Principles* were translated and published in 1777 by Hugh Brown, who also carried out the calculation of seventeen species of trajectories according to Euler's example and instructions. The like had been done previously by Grævenitz in 1764, as already stated, but the calculations appear to have been made independently. The weight of the ballistic pendulum used by Robins was only 56 lbs. 3 oz.

7. At Woolwich, in the year 1775, in conjunction with some able officers of the Royal Regiment of Artillery and other ingenious gentlemen, was first instituted a course of experiments on fired gunpowder and cannon-balls, similar to the course carried on afterwards during the years 1783–5, 1787–9, 1791, &c. Hutton's account of the earlier experiments was printed in the *Philosophical Transactions* for 1778, and was honoured with the annual medal of the Royal Society. Hutton[2] remarks, "That part of Mr Robins's "book has always been much admired, which relates to the experi-"mental method of ascertaining the actual velocities of shot, and "in *imitation* of *which*, but on a *large scale*, those experiments "were made which were described in my paper. Experiments in "the manner of Mr Robins were generally repeated by his com-"mentators, and others, with universal satisfaction; the method "being so just in theory, so simple in practice, and altogether so "ingenious that it immediately gave the fullest conviction of its

[1] New Principles, p. xl.

[2] Tracts, Vol. II. p. 307.

"excellence, and the eminent abilities of the inventor. The use "which our author made of his invention, was to obtain the real "velocities of bullets experimentally, that he might compare them "with those which he had computed *a priori* from a new theory "of gunnery, which he had invented, in order to verify the prin-"ciples on which it was founded. The success was fully answerable "to his expectations, and left no doubt of the truth of his theory, "at least when applied to such pieces and bullets as he had used. "These however were but small, being only musket balls of about "an ounce weight."

8. Hutton endeavoured to supply the want of results of experiments with larger balls by using shot from 1 lb. to near 3 lbs., and finally 6 lbs. in weight. He employed the ballistic pendulum of Robins, as that was at that time the only practical method of ascertaining the velocities of military projectiles, except that practised by Count Rumford, who suspended the gun and measured its recoil. Hutton commenced his experiments with a pendulum weighing between 500 and 600 lbs. in 1783; it was increased to 1014 lbs. in 1788; in the following year to 1655 lbs. and at last to 2099 lbs. Full particulars of the rounds fired have been carefully given. For the determination of resistances at low velocities Hutton used Robins's whirling machine.

9. Hutton states that his experiments of 1787, 88, 89 and 91 "were chiefly instituted to obtain the effects of the air's resistance "to balls in their rapid flight through it. To determine the "resistance to the very high velocities, were employed balls of "three several sizes, viz. of 2 inches, 2·78 inches, and 3·55 inches "in diameter. These were discharged with various degrees of "velocity, from 300 feet to 2000 feet in a second of time; and they "were also made to strike the pendulum block at several different "distances from the guns, in order to obtain the quantity of velo-"city lost, in passing through those spaces of air; whence the "degrees of resistance were obtained, appropriate to the different "velocities. These series of resistances for the three sizes of "balls above-mentioned, have been obtained in a state remarkably "regular, not only each series in itself, but also in comparison "with each other; the terms in every one of them following a "certain uniform law, in respect of the velocity, being indeed "nearly as the $2\frac{1}{10}$ power of the velocity; and the terms of any "one series also, as compared with the corresponding terms of

"another, with the same velocity, these being in a constant pro-"portion to one another," viz. as the surfaces of the balls moved "nearly, or as the squares of their diameters, with about $\frac{1}{20}$ part "more in counting from the less ball to the greater, or $\frac{1}{20}$ part less "when comparing the greater ball to the less[1]." Finally, Hutton expresses the resistance of the air in pounds to a spherical shot d inches in diameter, moving with a velocity v f.s.[2], by

$$(\cdot 000007565v^2 - \cdot 00175v)\, d^2.$$

10. The proposal to introduce some changes into the English Artillery in 1815 determined the director of the Royal Academy and Dr Gregory, professor in the same establishment, to cause a ballistic pendulum to be constructed *three times greater* than that of Hutton, with which to experiment with shot of 24 lbs. The weight of the pendulum was 7408 lbs. Shot of 6, 9, 12 and 24 lbs. were fired into the wooden block of this ballistic pendulum, *from guns of different lengths* with various charges[3]. Other experiments[4] were made in 1817, 18, at Woolwich to determine the influence of windage on the initial velocities of shot. The results obtained do not appear to have any permanent value.

11. General Piobert[5] recalculated the experiments of Hutton and obtained a formula of resistance

$$\rho = \pi R^2 \times 0\cdot 030586\,(1 + 0\cdot 0023\,V)\, V^2.$$

12. General Didion has remarked that the experiments made by Hutton in England on small projectiles "incomplètement "formulées par ce savant observateur" had for a long time formed the sole base of ballistic applications. Piobert had succeeded in representing Hutton's results by a formula of two terms. The experiments made at Metz in 1839 and 1840, on projectiles of service calibres, had enabled him to obtain coefficients of resistance applicable to *guns in actual use.* The coefficients deduced from the experiments of Hutton and from those obtained at Metz did not agree. But recalculating Hutton's experiments by a perfectly suitable method, and introducing the same corrections, he found there was no sensible difference between them. Shot of 8, 12, and 24, weighing respectively 8·86 lbs., 13·38 lbs. and 26·47 lbs., and also a shell of 8·66 inches, weighing 50·71 lbs. were used

[1] Tracts, III. pp. 216, 217. [2] Ib. p. 232.

[3] Ann. de Ch. et de Ph., V. p. 380. [4] Ib. IX.

[5] Mem. de l'Acad., 1836; and Didion, Lois, p. 22.

at Metz. The ballistic pendulum when filled with sand weighed about 6000 kilogrammes, or 13,228 lbs. All particulars of the experiments will be found in "*Lois de la Résistance de l'Air sur les Projectiles.*" Par Is. Didion, Paris, 1857. The consideration of all the experiments made with the ballistic pendulum led to the adoption of the formula $\rho = 0\cdot027\pi R^2 V^2 (1 + 0\cdot0023 V)$[1] in French measures, or to $r = 0\cdot0000028 d^2 v^2 (1 + 0\cdot0007 v)$ in English measures. Didion observes that the pendulum of Robins, formed of a simple plank of wood, suspended by a single bar, was the most susceptible of all to torsion and disturbances, and gave the highest result; that the pendulum of Hutton better constructed and suspended by *two* bars, gave results higher with the 3 lb. and 6 lb. balls than with the 1 lb. ball; and that these were higher than those of the experiments made at Metz with a very massive pendulum suspended by *four* bars, and very rigid.

From these considerations Didion concludes that the divergences observed proceeded from the imperfection of the apparatus, and that the lower results obtained with the apparatus

Velocity	Hutton 1791	Correction required	Didion 1840	Correction required	Bashforth 1868
f. s.	lbs.	lbs.	lbs.	lbs.	lbs.
100	0·2		0·1		
200	0·7		0·5		
300	1·6		1·2		
400	2·9		2·3		
500	4·7		3·8		
600	6·9		5·7		
700	9·8		8·2		
800	13·3		11·2		
900	17·5	−4·7	14·8	−2·0	12·8
1000	22·6	−5·0	19·0	−1·4	17·6
1100	28·6	−3·1	24·0	+1·5	25·5
1200	35·3	−1·9	29·7	+3·7	33·4
1300	42·7	−2·1	36·2	+4·4	40·6
1400	50·7	−2·2	43·5	+5·0	48·5
1500	59·2	−2·5	51·7	+5·0	56·7
1600	67·9	−2·6	60·8	+4·5	65·3
1700	76·8	−2·7	70·9	+3·2	74·1
1800	85·5	−2·6	82·0	+0·9	82·9
1900	94·1	−1·3	94·2	−1·4	92·8
2000	102·4	+1·9	107·5	−3·2	104·3

[1] Lois, &c., p. 78.

the most recent and most improved, and which are moreover the most numerous and obtained with *service* projectiles, ought to be regarded as the most exact.

13. The foregoing Table shows the resistance of the air to the motion of a spherical ball 2 inches in diameter, (1) as given by Hutton; (2) as calculated by Didion's formula; and (3) as calculated by the help of my own coefficients, 1868.

From the above table it appears that Didion was quite right when he declared that Hutton's results were too high. But he over-corrected them, and gave a formula which produced results that were too low. In fact for velocities 1200 to 1700 feet per second, Hutton's results were nearer the truth than Didion's.

14. Hutton expressly denied that there was any "shifting of "the resistance of the air" at or about the velocity of sound, such as Robins had pointed out[1]; while Didion gave a formula for the resistance of the air of the form

$$AV^2(1+BV) = AV^3\left(\frac{1}{V}+B\right),$$

so that the coefficient of V^3 increases as V decreases; but my experiments show that there is a sudden decrease in the value of this coefficient in the neighbourhood of the velocity of sound.

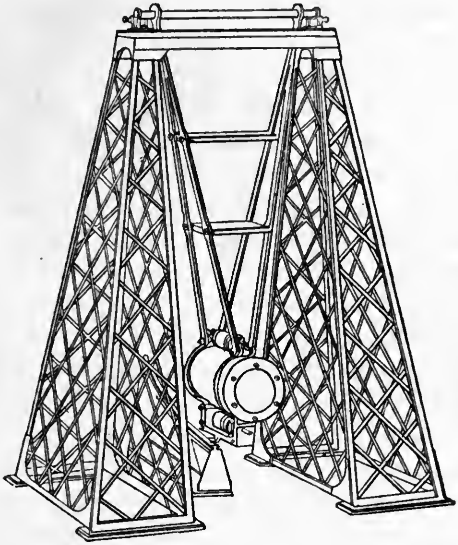
It gives me great pleasure to exhibit the valuable work done by these early experimenters, who worked together in the best possible spirit—each ready to recognise the value of his predecessor's work. Hutton brought out a new edition of Robins's *New Principles*, &c., while Didion recalculated Hutton's experiments.

15. Finally a monster ballistic pendulum was constructed for the English Government in 1855 by Messrs Armstrong and Co. It was first set up at Shoeburyness, afterwards removed to Woolwich, and finally dismantled without ever having been used in any course of experiments. It therefore gave no results. But still an elaborate model of this useless instrument was made for the Great Exhibition of 1862, which was reported to have cost £800. I do not know what was the weight of the pendulum-block in this case. The figure represents this ballistic pendulum, which was about twenty feet in height.

16. It was perhaps natural that each succeeding experimenter should be anxious to use shot of increased weight which involved

[1] Hutton's edition of Robins, p. 181.

the employment of heavier pendulum blocks. But on reviewing the work that has been done, it appears probable that the ex-



perimenters who followed Robins would have succeeded better if they had expended all their care and ingenuity upon experiments on a *small* scale. For Robins noticed a change in the law of resistance which was disputed or passed over in silence by succeeding experimenters with the ballistic pendulum. Now it is impossible to experiment satisfactorily with small-arm bullets by the help of *galvanic* chronographs, because they would generally pass between the strings of the screens without cutting them, or they would be rendered *unsteady* if they touched the threads of the screen. But with the great precision of the small arms now made there would be no difficulty in carrying out experiments with a *light* ballistic pendulum. I find that care was taken by the old experimenters to screen the block of the ballistic pendulum from the blast of the gun, but I have not noticed that any attempt was made to prevent the blast of air, which accompanies a shot, from acting upon the pendulum. It would be well therefore to place a thin paper screen just in front of the block of the pendulum, the bull's eye being marked on the paper in front of the point to be hit.

17. When I commenced experimenting in 1864 with a view to determine the resistance of the air to the motion of projectiles, the best results previously obtained were those derived from the use of the ballistic pendulum. The electro-ballistic instruments of Vignotti, Navez, Leurs, and others of the same type, were liable to frequent errors, and so were not adapted for use in determining the resistance of the air to projectiles. The want of an instrument capable of measuring the times occupied by a shot in passing over *a succession of equal spaces* was felt long ago, for in 1843 Col. Konstantinoff employed M. Bréguet, of Paris, to construct for him a chronograph. "Le problème était celui-ci: Disposer "un instrument qui pût indiquer et conserver trente ou quarante "observations successives, faites dans des espaces de temps tres "rapprochés, d'un phénomène se passant plus ou moins loin de "l'endroit où se trouve placé l'instrument d'observation[1]." The construction of the instrument was commenced in June, 1843, and completed on the 29th of May, 1844[2]. This instrument is described and figured by Du Moncel[3]. Hence arose a warm discussion between Wheatstone and Bréguet[4] of which Moigno[5] has given a long account. It is difficult to say what the dispute was all about, as it does not appear that results of any value were ever obtained by either party, for in 1856 Morin remarked that the problem had not even then been resolved in a way completely satisfactory. Du Moncel remarks, "Ce chronographe "fut, en 1845, l'object d'une discussion assez animée entre MM. "Wheatstone et Bréguet, de laquelle il est résulté que la *première* "*idée* des chronoscopes et chronographes électriques appartenait "bien à M. Wheatstone, mais que c'était au capitaine Konstanti-"noff que revenait *l'idée* d'enrigistrer la vitesse des projectiles aux "différents points de leur trajectoire, et à M. Bréguet que devait "être attribuée la disposition de l'instrument pour résoudre le "problème posé par M. Konstantinoff[6]."

18. Another chronograph, the invention of Captain Schultz, was exhibited at Paris in 1867, which was intended to register several records for each round. We were informed that "Captain "Schultz, in fact, finds that he can observe and register time to

[1] Moigno, Télégraphie, 1849, p. 95.
[2] Ib. p. 96.
[3] Applications, II. p. 337, 1856.
[4] Comptes-Rendus, 1845.
[5] Télégraphie, pp. 88—113.
[6] Applications, II. p. 337.

"$\frac{1}{10000000}$ of a second[1]!" Either the Ordnance Select Committee or the Committee on Explosives were not slow in securing such a promising instrument. But when they had got it they could not make it work, for although I inquired frequently, I could not learn that they had obtained any results fit to produce. The most elementary knowledge of the subject ought to have warned them that there were *three* objections to the satisfactory working of this chronoscope, any one of which would prove fatal:—(1) the badly contrived system of screens, (2) the use of the tuning-fork to divide the second of time, and (3) the use of the spark as the recording agent. The Schultz chronoscope was early used in the United States, but from Lt.-Col. Benet's[2] account, it appears to have only been applied to measure *initial* velocities. In this respect he speaks favourably of the instrument. But Captain Ingalls[3] has explained how the case stands now. He remarks, "the only "chronograph which can successfully compete with Bashforth's as "a means for studying the resistance of the air was invented by "Captain Schultz of the French Artillery, in 1864, the year in "which Professor Bashforth constructed his first instrument. "*Since that time it has been much improved by* M. Marcel-Deprez, "Lt.-Colonel Sébert of the French Marine Artillery, and Lieu-"tenant A. H. Russell of the U. S. Ordnance; and all the objec-"tionable features mentioned by the Bashforth committee have "been obviated. *As thus modified* it is strikingly like Professor "Bashforth's chronograph, and the same screens, batteries, arrange-"ments of circuits, and methods of reduction of observations can "be used in both." Still we have no results obtained by the use of this "modified" instrument, which was brought forward at Woolwich in its crude state in opposition to mine 20 years ago with little credit to its patrons.

[1] Practical Mechanic's Journal, Oct. 1867, p. 195.

[2] Electro-Ballistic Machines, 1866. [3] Ballistic Machines, 1885, p. 29.

CHAPTER II.

DESCRIPTION OF THE CHRONOGRAPH, WITH AN ACCOUNT OF EXPERIMENTS AND THEIR REDUCTION.

19. On the institution of the Advanced Class of Royal Artillery Officers at Woolwich in 1864 the Professorship of Applied Mathematics was offered to me by the Council of Military Education. I the more readily accepted that office because I saw my way to the satisfactory solution of the problem of the resistance of the air to the motion of projectiles. It was also a part of my duty to act as referee to the Ordnance Select Committee, at that time the scientific advisers of the Government. The Committee were possessors of the monster ballistic pendulum of 1855, which was useless, and electro-ballistic instruments of the type of Navez, which were unreliable, because they afforded no means of testing the accuracy of their results. I therefore submitted to the committee my plans for the construction of a chronograph adapted to record the times occupied by any shot in passing over a succession of equal spaces, for, if these records were found consistent with each other, or capable of being made so by allowable corrections, then the results must be trustworthy, supposing the law of resistance of the air not to be subject to any sudden change. This supposition has been found to be correct, except perhaps for velocities 1000—1100 f. s., where there is a rapid change in the law of resistance. But the Ordnance Select Committee did not require any new chronograph for their purposes, as they were at that time quite satisfied with the Navez chronoscope they possessed. It was perhaps fortunate that, for this reason, I was obliged to keep the construction of the new instrument in my own hands, for thus I was able to introduce improvements in any part which was found to be defective in the original design.

20. After a due consideration of all circumstances of the case, it appeared that the following conditions must be satisfied by a chronograph to be worthy of perfect confidence:—

(1) The time to be measured by a clock going uniformly.

(2) The instrument to be capable of measuring the times occupied by a cannon-ball in passing over at least *nine* successive *equal* spaces.

(3) The instrument to be capable of measuring the longest known time of flight of a shot or shell.

(4) Every beat of the clock to be recorded by the *interruption* of the same galvanic current, and under precisely *the same conditions.*

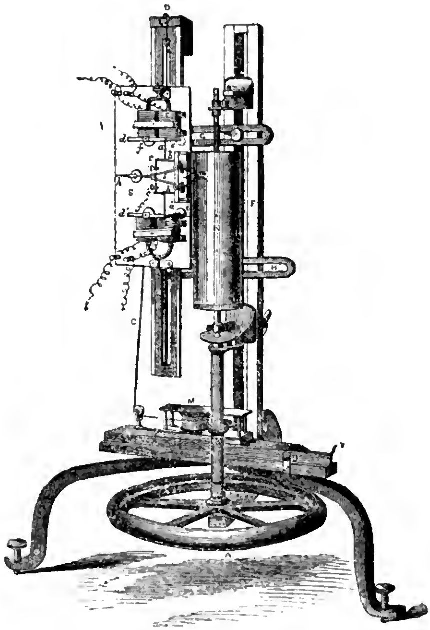
(5) The time of passing each screen to be recorded by the momentary *interruption* of a second galvanic current, and under precisely *the same conditions.*

(6) Provision to be made for keeping the strings or wires of the screens in *a uniform state of tension*, notwithstanding the force of the wind and the blast accompanying the ball.

21. The following is a description of the chronograph as constructed, and of various useful appendages. Fig. 3 gives a general view of the chronograph. A is a fly-wheel capable of revolving about a vertical axis, and carrying with it the cylinder K, which is covered with prepared paper for the reception of the clock and screen records. The length of the cylinder is 12 or 14 inches, and the diameter 4 inches. B is a toothed-wheel which gears with the wheelwork M so as to allow the string CD to be slowly unwrapped from its drum. The other end of CD being attached to the platform S allows it to descend slowly along the slide L, about $\frac{1}{4}$ inch for each revolution of the cylinder. E, E' are electro-magnets; d, d' are frames supporting the keepers; and f, f' are the ends of the springs which act against the attraction of the electro-magnets. When the current is interrupted in one circuit, as E, the magnetism of the electro-magnet is destroyed, the spring f pulls back the keeper, which turns about a hinge at d, and by means of the arm a, *gives a blow* to the lever b. Thus the marker m is made to depart suddenly from the uniform spiral it was describing. When the current is restored the keeper is attracted, and thus the marker m is brought back, which con-

tinues to trace its spiral as if nothing had happened. *E'* is connected with the clock, and its marker *m'* records the seconds.

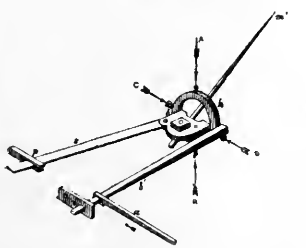
Fig. 3.



E is connected with the screens, and records the passage of the shot through the screens. By measuring up the marks made by *m*, *m'* the exact velocity of the shot can be calculated at all points of its course. The slide *L* is fixed parallel to *F* and the cylinder *K* by the brackets *G*, *H*. *Y* is a screw for drawing back the wheel-work *M*, and *J* a stop to regulate the distance between *M* and *B*. The depression of the lever *h* raises the two springs *s*, which act as levers, and bring the diamond points *m*, *m'* down upon the paper. When an experiment is to be made, care is taken to see that the two currents are complete. The fly-wheel *A* is set in motion by hand, so as to make about three revolutions in two seconds. The markers *m*, *m'* are brought down upon the paper, and after one or two beats of the clock the signal to fire is given, so that in about five seconds the experiment is completed, and the instrument is ready for another.

22. Fig. 4 gives a view of one of the markers, showing the way in which it is moved. The depression of the lever *h* (Fig. 3), raises *p*, and thus the lever *s*, which is formed of watch-spring wire, brings down m' to the paper, and keeps it gently in contact. This motion takes place within the circle *k*, about an axis *CD*. a' is an arm connected with the electro-magnet. When the magnetism in E' is destroyed, a' begins to move away, and when it has moved a short distance it *strikes* the lever b' a *sudden blow* which carries it as far as the hole in the stop c' will allow it to move. The lever b' is rigidly connected with the circle *k*, which is capable of moving about an axis *AB*. This motion is communicated to m', which describes a very short arc of a circle about a point in *AB*. The arrangement is so made that when either of the markers m, m' is making a record, it has a motion which may be resolved partly in *direction of the motion* of the paper under it, and partly in a direction perpendicular to this. When these adjustments are properly made the records to be read off will be nearly at right angles to the spirals.

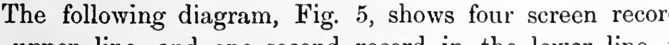
Fig. 4.



The pendulum of a half-seconds clock strikes once each double-beat a very light spring, and so interrupts the galvanic current in E' once a second.

The following diagram, Fig. 5, shows four screen records in the upper line, and one second record in the lower line, when the markers are properly adjusted.

Fig. 5.



23. Figs. 6 and 7 give the details of the screens. Fig. 6 represents a piece of board 1 inch thick and 6 or 7 inches wide,

and rather longer than the width of the screen to be formed. Transverse grooves are cut at equal distances, something less than the diameter of the shot, as shown in the diagram. Staples

Fig. 6.

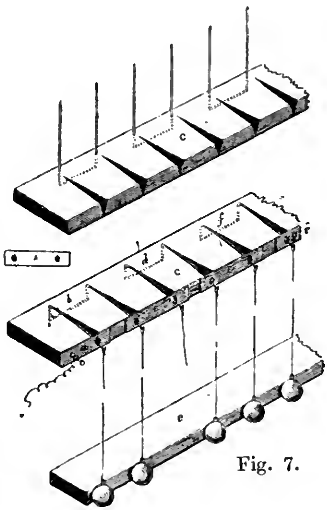
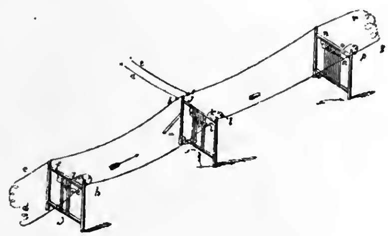


Fig. 7.

of hard brass spring-wire (No. 14 or 15), are fixed with their prongs in the continuation of the grooves. Pieces of sheet copper *A* are provided, having two elliptical holes, the distance of whose centres equals the distance of the grooves. The pieces of copper *A* are used to connect each wire staple, as *C*, with its neighbour on each side. Thus, Fig. 7 *a*, *c*, *e*, *g*, &c., represent these copper connections put in their places and holding down the wire springs, which, when free, are in contact with the tops of the holes; but, when properly weighted, they rest on the lower edge of the holes. Thus the copper *c* forms a connexion between the staples *b* and *d*; the copper *e* joins *d* and *f*, and so on. A galvanic current will therefore take the following course, whether the springs be weighted or unweighted: copper *a*, brass *b*, copper *c*, brass *d*, copper *e*, brass *f*, copper *g*, &c. The current will only be interrupted when one or more threads have been cut and the corresponding spring is flying from the bottom to the top of its hole. About $\frac{1}{50}$th of a second is required for the complete registration of such an interruption, the spring traversing about half an inch. The shelf *B* is placed for the weights to rest against, partly to prevent them from being carried forward by the shot, but chiefly to prevent the untwisting of the threads which support the weights. The weights used were about 2 lbs. each, and the strength of the sewing cotton for supporting them was equal to a stress of about 3 lbs., which was sufficient to withstand a tolerably strong wind. As the weights were equal the threads were kept *equally* stretched.

24. The arrangement of the screens for an experiment is shown in Fig. 8. The wires for conveying the galvanic current

Fig. 8.

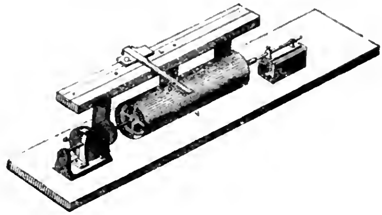


are, like the common telegraph wire, carried on posts. *abc* is a continuous piece of wire; but there are interruptions between *e* and *h*, between *i* and *l*, between *m* and *p*, &c., in order to make the galvanic current circulate through the screens. The course of the galvanic current is *a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t.* The ends *a, t,* are connected with the instrument and battery. The shot, being fired through the screens, in passing cuts one or more threads at each screen, so that corresponding to the instant at which the shot passes each screen there is an interruption of the galvanic current, and a simultaneous record on the paper cylinder.

25. When the cylinder is filled with spirals, that is after five or six rounds, it is transferred to the instrument, Fig. 9, where *a* is a circle divided into 300 equal parts, and the division is carried to 3000 by the help of a vernier. A small T-square, having a fine edge at *b*, moves along a brass straight-edge *L*, adjusted so as to be parallel to the axis of the cylinder. The mark *b* is carefully placed opposite each record on the paper by means of a tangent screw (not shown in the figure), and the

vernier is read. It would have been more convenient if the circle had been divided into 500 rather than 300 equal parts.

Fig. 9.



The clock goes on breaking the galvanic circuit every swing of the pendulum, whether the marker *m'* be in contact with the paper or not—consequently, whatever be the loss of time in the action of the marker, we may fairly suppose it to be constant. But if the current had been circulating through the screens for several minutes, or even seconds, without interruption before the shot was fired, the records at the first and the following screens would not have been made under the *same* conditions.

26. To guard against any error from this source, an ordinary self-acting spring contact breaker was introduced into the screen circuit. The raising of a spring lever interrupts the main current of galvanism through the screens. The insertion of a pin to keep up the lever, re-opens a passage for the screen galvanic current through the contact breaker; this may be made also to ring a bell in the instrument room, to give notice that all things are ready for the experiment. The fly-wheel is then put in motion, the signal to fire is given; the pulling of the lanyard withdraws the pin and so restores the main current, and then fires the gun.

27. The construction of the chronograph was commenced in August, 1864; it was ready for trial in June, 1865. It received its first *partial* trial before the Committee on Gun Cotton in July 1865, in conjunction with Major Navez's Electro Ballistic Pendulum. The instruments gave a nearly constant difference of 20 f.s. in velocities of about 1500 f.s. The chronograph remained at the proof butts from July to November, 1865, when it was taken down to Plumstead Marshes and placed in a splinter-

proof, where it remained about a fortnight. Its powers to withstand damp and dust were well tested in this manner.

28. In carrying out a series of experiments it is advisable to provide convenient means for *interrupting* the *clock* galvanic current when the markers are raised. It is also desirable to have the means of *diverting* the *screen* galvanic current from its electro-magnet to another adapted to ring a small bell in the instrument room, for then it is known what is going on on the range, if the circuit be not broken. These three operations of raising the markers, breaking the clock current and diverting the screen current might be effected by one motion, if the stage *e′d′de* (Fig. 3) between the fixed electro-magnets *E*, *E′* was made to rotate about its back edge *dd′*. Then, when preparing to fire a round it would only be necessary to press down the platform *d′e* to make everything ready for a new experiment.

29. As it is quite impossible to drive the cylinder which receives the records with a sufficiently *uniform* and known angular velocity, it was decided to place the axis in a vertical position in the manner shown in Fig. 3, and spin the instrument by hand. When the records of a successful experiment are read off, they show slight irregularities, which must be corrected so as to make the readings yield regular differences. The scale of time found in this way is a decreasing scale. By interpolation the places are found where the records for every *tenth* of a second would fall. On comparing the screen records, it is now possible to read off the time each screen was passed to the tenth of a second by the scale of time, and any remaining fraction of one-tenth of a second is found by proportional parts, on the supposition that the angular velocity of the cylinder is uniform for each tenth of a second. At first the time of passing each screen was expressed to *four* places of decimals of a second, which seemed quite sufficient for all practical purposes, but to secure satisfactory results it was found necessary to go to *five* places of decimals of a second. When this had been done, further extremely small corrections were required to make the calculated times of passing the screens difference properly. I will give round 148; hollow ogival headed shot, $d = 4{\cdot}92$ in.; $w = 23{\cdot}84$ lbs. as it was printed in the Report, Feb. 1869[1]; carried to four places of decimals, and also in the form in which it appears after the recent revision. The following

[1] Reports, &c. 1865—1870, p. 56.

statement gives the original readings and the corrections applied to them.

Clock

	Readings	corn.	cord. readings	Δ¹	Δ²
2	19·27	0	= 19·270	+24·280	
3	43·55	0	= 43·550	+24·208	−72
4	67·78	−·022	= 67·758	+24·136	−72
5	91·89	+·004	= 91·894	+24·065	−71
6	115·95	+·009	= 115·959	+23·995	−70
7	139·96	−·006	= 139·954	+23·926	−69
8	163·88	0	= 163·880		

Screens

	Readings	corn.	cord. readings	Δ¹	Δ²
1	78·61	−·002	= 78·608	+2·627	
2	81·23	+·005	= 81·235	+2·684	+57
3	83·92	−·001	= 83·919	+2·741	+57
4	86·67	−·010	= 86·660	+2·798	+57
5	89·46	−·002	= 89·458	+2·855	+57
6	92·31	+·003	= 92·313	+2·911	+56
7	95·22	+·004	= 95·224	+2·969	+58
8	98·20	−·007	= 98·193	+3·028	+59
9	101·22	+·001	= 101·221	+3·087	+59
10	104·31	−·002	= 104·308		

30. By interpolation the clock readings were found for every tenth of a second. By the help of proportional parts the screen readings were converted into seconds, as follows

I. (1868)[1]

Screen	t	Δt	$\Delta^2 t$
1	4″·4492	+1088	
2	4·5580	+1113	+25
3	4·6693	+1136	+23
4	4·7829	+1160	+24
5	4·8989	+1185	+25
6	5·0174	+1208	+23
7	5·1382	+1233	+25
8	5·2615	+1258	+25
9	5·3873	+1282	+24
10	5·5155		

II. (1889)

Screen	t	Δt	$\Delta^2 t$	$\Delta^3 t$
1	4″·44917	+10885		
2	4·55802	+11124	+239	
3	4·66926	+11363	+239	0
4	4·78289	+11603	+240	+1
5	4·89892	+11844	+241	+1
6	5·01736	+12086	+242	+1
7	5·13822	+12330	+244	+2
8	5·26152	+12576	+246	+2
9	5·38728	+12824	+248	+2
10	5·51552			

31. We must now show how the velocity v and the retarding force f of the air upon the shot may be deduced from the results of experiments so expressed.

By Finite differences we have

$$\Delta t_s = t_{s+l} - t_s,$$

or

$$t_{s+l} = t_s + \Delta t_s,$$

$$t_{s+2l} = t_{s+l} + \Delta t_{s+l} = t_s + 2\Delta t_s + \Delta^2 t_s,$$

$$t_{s+3l} = t_s + 3\Delta t_s + 3\Delta^2 t_s + \Delta^3 t_s,$$

&c. &c.

[1] Ib. p. 30.

And generally

$$t_{s+nl}=t_s+n\Delta t_s+\frac{n\,.\,\overline{n-1}}{1\,.\,2}\Delta^2t_s+\frac{n\,.\,\overline{n-1}\,.\,\overline{n-2}}{1\,.\,2\,.\,3}\Delta^3t_s+\&c.$$

$$=t_s+n\,\{\Delta t_s-\tfrac{1}{2}\Delta^2t_s+\tfrac{1}{3}\Delta^3t_s-\tfrac{1}{4}\Delta^4t_s+\&c.\}$$

$$+\,n^2\,\{\tfrac{1}{2}\Delta^2t_s-\tfrac{1}{2}\Delta^3t_s+\tfrac{11}{24}\Delta^4t_s-\tfrac{10}{24}\Delta^5t_s+\tfrac{137}{360}\Delta^6t_s+\&c.\}+\&c.$$

Expanding t_{s+nl} by Taylor's Theorem, we have

$$t_{s+nl}=t_s+\frac{dt_s}{ds}\frac{nl}{1}+\frac{d^2t_s}{ds^2}\frac{n^2l^2}{1\,.\,2}+\frac{d^3t_s}{ds^3}\frac{n^3l^3}{1\,.\,2\,.\,3}+\&c.,$$

and equating the two coefficients of n and of n^2 in the two expansions of t_{s+nl}, we have

$$l\frac{dt_s}{ds}=\Delta t_s-\tfrac{1}{2}\Delta^2t_s+\tfrac{1}{3}\Delta^3t_s-\tfrac{1}{4}\Delta^4t_s+\tfrac{1}{5}\Delta^5t_s-\&c.,$$

and
$$l^2\frac{d^2t_s}{ds^2}=\Delta^2t_s-\Delta^3t_s+\tfrac{11}{12}\Delta^4t_s-\tfrac{10}{12}\Delta^5t_s+\tfrac{137}{180}\Delta^6t_s+\&c.$$

$$=(\Delta^2t_{s-l}+\Delta^3t_{s-l})-(\Delta^3t_{s-l}+\Delta^4t_{s-l})+\tfrac{11}{12}(\Delta^4t_{s-l}+\Delta^5t_{s-l})$$

$$-\tfrac{10}{12}(\Delta^5t_{s-l}+\Delta^6t_{s-l})+\tfrac{137}{180}(\Delta^6t_{s-l}+\Delta^7t_{s-l})-\&c.$$

$$=\Delta^2t_{s-l}-\tfrac{1}{12}\Delta^4t_{s-l}+\tfrac{1}{12}\Delta^5t_{s-l}-\tfrac{13}{180}\Delta^6t_{s-l}-\&c.$$

$$=\Delta^2t_{s-l}-\tfrac{1}{12}\Delta^4t_{s-2l}+\tfrac{1}{90}\Delta^6t_{s-3l}-\&c.$$

32. Also by expanding t_{s-nl} in the same way by Finite Differences and by Taylor's Theorem, it may be shown that

$$l\frac{dt_s}{ds}=\Delta t_{s-l}+\tfrac{1}{2}\Delta^2t_{s-2l}+\tfrac{1}{3}\Delta^3t_{s-3l}+\tfrac{1}{4}\Delta^4t_{s-4l}+\&c.$$

and
$$l^2\frac{d^2t_s}{ds^2}=\Delta^2t_{s-2l}+\Delta^3t_{s-3l}+\tfrac{11}{12}\Delta^4t_{s-4l}+\tfrac{5}{6}\Delta^5t_{s-5l}+\&c.$$

33. Let s denote the distance from some fixed point to a screen, l the distance between successive screens, and t_{s-2l}, t_{s-l}, t_s, t_{s+l}, t_{s+2l} ... the observed times of the shot passing successive screens. Then if v_s denote the velocity of the shot, and f_s the retarding force of the air upon the shot at the time t_s,

$$v_s=\frac{ds}{dt_s}=\frac{l}{\Delta t_s-\frac{1}{2}\Delta^2t_s+\frac{1}{3}\Delta^3t_s-\frac{1}{4}\Delta^4t_s+\frac{1}{5}\Delta^5t_s-\&c.},$$

also
$$=\frac{l}{\Delta t_{s-l}+\frac{1}{2}\Delta^2t_{s-2l}+\frac{1}{3}\Delta^3t_{s-3l}+\frac{1}{4}\Delta^4t_{s-4l}+\frac{1}{5}\Delta^5t_{s-5l}+\&c.},$$

and $$f_s = \frac{d^2s}{dt_s^2} = -\frac{d^2t_s}{ds^2}\left(\frac{ds}{dt_s}\right)^3$$

$$= -\frac{v_s^3}{l^2}\left(\Delta^2 t_{s-l} - \tfrac{1}{12}\Delta^4 t_{s-2l} + \tfrac{1}{90}\Delta^6 t_{s-3l} - \&c.\right).$$

The following scheme explains how these differences are to be taken

$$\begin{array}{ccccccc}
 & & & +\Delta^3 t_{s-4l} & & & \\
t_{s-2l} & & +\Delta^2 t_{s-3l} & & +\Delta^4 t_{s-4l} & & \\
 & +\Delta t_{s-2l} & & +\Delta^3 t_{s-3l} & & +\Delta^5 t_{s-4l} & \\
t_{s-l} & & +\Delta^2 t_{s-2l} & & +\Delta^4 t_{s-3l} & & +\Delta^6 t_{s-4l} \\
 & +\Delta t_{s-l} & & +\Delta^3 t_{s-2l} & & +\Delta^5 t_{s-3l} & \\
t_s & & +\Delta^2 t_{s-l} & & +\Delta^4 t_{s-2l} & & +\Delta^6 t_{s-3l} \\
 & +\Delta t_s & & +\Delta^3 t_{s-l} & & +\Delta^5 t_{s-2l} & \\
t_{s+l} & & +\Delta^2 t_s & & +\Delta^4 t_{s-l} & & +\Delta^6 t_{s-2l} \\
 & +\Delta t_{s+l} & & +\Delta^3 t_s & & +\Delta^5 t_{s-l} & \\
t_{s+2l} & & +\Delta^2 t_{s+l} & & +\Delta^4 t_s & & +\Delta^6 t_{s-l} \\
 & +\Delta t_{s+2l} & & +\Delta^3 t_{s+l} & & +\Delta^5 t_s & \\
t_{s+3l} & & * & & * & & * \\
 & * & & * & & * &
\end{array}$$

34. Let v_5 denote the velocity of the shot at the 5th screen, f_5 the retarding force at the same point, and $l = 150$ feet, in round 148, then we have

$$v_5 = \frac{150}{\Delta t_s - \frac{1}{2}\Delta^2 t_s + \frac{1}{3}\Delta^3 t_s - \&c.}$$

$$= \frac{150}{\cdot 11844 - \frac{1}{2}\cdot 00242 + \frac{1}{3}\cdot 00002 - \&c.} = 1279\cdot 5 \text{ f. s.}$$

and $$f_5 = -\frac{v_5^3}{l^2}\left(\Delta^2 t_{s-l} - \tfrac{1}{12}\Delta^4 t_{s-2l} + \&c.\right)$$

$$= -\frac{v_5^3}{(150)^2}(\cdot 00241) = -2bv_5^3.$$

But when this experiment was made the weight of a cubic foot of air was 534·55 grains, and the standard weight 534·22 grains.

Hence $$K_{v_5} = 2b\,(1000)^3\,\frac{w}{d^2}\,\frac{534\cdot 22}{534\cdot 55}$$

$$= \frac{\cdot 00241}{(150)^2}(1000)^3\,\frac{23\cdot 84}{(4\cdot 92)^2}\,\frac{534\cdot 22}{534\cdot 55} = 105\cdot 4.$$

In the same way the corresponding values of v and K_v may be found at each screen, as follows

Screen	v	Δv	$\Delta^2 v$	K_v	Δ
	f. s.				
2	1363·0	−28·9		104·5	0
3	1334·1	−27·8	+1·1	104·5	+·5
4	1306·3	−26·8	+1·0	105·0	+·4
5	1279·5	−25·8	+1·0	105·4	+·5
6	1253·7	−24·9	+0·9	105·9	+·8
7	1228·8	−24·2	+0·7	106·7	+·9
8	1204·6	−23·4	+0·8	107·6	+·9
9	1181·2			108·5	

35. Thus round 148 gives the following values of K_v

v	K_v		v	K_v		v	K_v	
f. s.			*f. s.*			*f. s.*		
1360	104·5	0	1300	105·1	+·1	1240	106·3	+·4
1350	104·5	0	1290	105·2	+·2	1230	106·7	+·3
1340	104·5	+·1	1280	105·4	+·2	1220	107·0	+·4
1330	104·6	+·1	1270	105·6	+·2	1210	107·4	+·4
1320	104·7	+·1	1260	105·8	+·2	1200	107·8	+·4
1310	104·9	+·2	1250	106·0	+·3	1190	108·2	

Each of these values of K_v will be found under its proper velocity v in the Summary.

36. The Chronograph when tried with 10 equidistant screens in November and December 1865, in Plumstead Marshes, proved successful. Eighteen rounds in all were fired through ten screens 120 feet apart from the Armstrong 12 Pr. B. L. gun. The diameter of the shot was 3 inches, and its weight about 12 lbs., but no particular care was taken to weigh the shot, as the only object of the experiment was simply to test the working of the instrument. Of the eighteen rounds, two were fired by mistake, while the cylinder was stationary. One shot carried away a screen, and another cut the conducting wire at the second screen. But I was able to give a good account of eleven out of the eighteen rounds fired to test the Chronograph.

37. The following is a statement of the results of this trial experiment, where d denotes the diameter in inches and w the weight of the shot in pounds, and l the distance in feet between successive screens.

Report dated December 18, 1865.

$d = 3$ in., $w = 12$ lbs., $l = 120$ feet.

Round	Screen 1.	Screen 2.	Screen 3.	Screen 4.	Screen 5.	Screen 6.	Screen 7.	Screen 8.	Screen 9.	Screen 10.
1	0″·0	·10640	·21409	·32297	·43293	·54386	·65564	·76816	·88131	·99498
2	0·0	·10450	·20981	·31609	·42349	·53215	·64220	·75376	·86694	·98184
5	0·0	·10461	·21025	·31694	·42472	·53365	·64381	·75530	·86826	—
7	0·0	·10335	·20872	·31567	·42386	·53305	·64310	·75398	·86577	·97866
10	0·0	·10540	·21164	·31891	·42732	·53694	·64786	·76008	·87360	·98842
11	0·0	·10467	·21096	·31877	·42800	·53855	·65032	·76321	—	—
13	0·0	·10505	·21110	·31830	·42670	·53630	·64710	·75910	·87228	·98660
15	0·0	·10420	·21010	·31750	·42620	·53600	·64670	·75810	—	—
16	0·0	·10495	·21120	·31875	·42760	·53775	·64917	·76182	·87567	·99072
17	0·0	·10506	·21147	·31924	·42838	·53890	·65080	·76409	·87877	·99484
18	0·0	·10572	·21239	·32004	·42872	·53850	·64947	·76173	·87538	·99052
Means	0·0	·10490	·21107	·31847	·42708	·53688	·64783	·75994	·87311	·98832

38. Thus it appears that the average of the mean times of passing each screen was

Screen	dist. feet	t	Δt	$\Delta^2 t$
1	0	0″·0000	1049	
2	120	·1049	1062	13
3	240	·2111	1074	12
4	360	·3185	1086	12
5	480	·4271	1098	12
6	600	·5369	1109	11
7	720	·6478	1121	12
8	840	·7599	1132	11
9	960	·8731	1152	20
10	1080	·9883		

As $\Delta^2 t$ was here found to be nearly constant it was assumed that the space s described in the time t were connected by the equation

$t = as + bs^2$, which gives $v = \dfrac{ds}{dt} = \dfrac{1}{a + 2bs}$,

and
$$f = \frac{d^2 s}{dt^2} = -\frac{2bv}{(a+2bs)^2} = -2bv^3,$$

or the resistance appeared to vary approximately as the cube of the velocity for this short range.

CHAPTER III.

EXPERIMENTS WITH THE CHRONOGRAPH.

39. In the next place, some experiments were authorised to be made at Shoeburyness with elongated projectiles having hemispherical, hemispheroidal, and ogival heads struck with radii of one and of two diameters of the shot. These experiments were carried out on Sept. 25, 26, and 27, 1866. The firing was often interrupted by passing ships, and on the 28th not a single experimental round could be safely fired. As only 44, out of the 70 shots provided were fired, and there was never an opportunity to complete the experiment, the results were not quite so satisfactory as they should have been. But all the hollow ogival headed shot of one and of two diameters were fired alternately, and this constitutes one of the best experiments of the kind ever performed. In order to avoid any confusion in numbering the rounds between the parties on the range and in the observing room it was usual to note at both places the exact time of firing every round. This arrangement enables me to state that the rounds 23—31 were fired in 44 min. 50 sec., and these nine rounds gave 89 good records. The following is a statement of the particulars of each round[1]. The results of these experiments were applied to calculate tables of remaining velocities for each form of shot used. The screens were 150 feet apart.

[1] Reports, &c. 1865—1870, p. 10, and Transactions of the Royal Society, 1868, p. 417.

40. Report dated Oct. 23, 1866.

No. of Round	Weight.	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
	lbs.				Hemispherical-headed Projectiles.						
1	39·344	0″·0	·12639	·25467	·38481	·51678	·65055	·78609	·92337	1·06236	1·20303
5	39·310	0·0				·00000	·13330	·26810	·40440	·54220	·68150
13	39·330	0·0	·12669	·25487	·38456	·51578	·64855	·78289	·91882	1·05636	1·19553
34	39·340	0·0	·12670	·25500	·38490	·51643	·64962	·78450	·92110	1·05945	1·19958
43	39·340	0·0	·12596	·25361	·38297	·51406	·64690	·78151	·91791	1·05612	1·09616
					Hemispheroidal-headed Projectiles.						
2	38·72	0·0	·12662	·25444	·38352	·51392	·64570	·77892	·91364	*	*
7	38·69	0·0	·12721	·25582	·38583	·51724	·65005	·78426	·91987	1·05688	*
35	38·69	0·0	·12677	·25482	·38415	·51478	·64673	·78002	·91467	1·05070	1·18813
40	38·69	0·0	·12640	·25416	·38329	·51380	·64570	·77900	·91370	1·04980	1·18730
					Solid Ogival-headed Projectiles (one diameter).						
3	39·56	0·0	·12910	·25997	·39261	·52702	·66320	·80115	·94087	*	*
36	39·56	0·0	·12642	·25430	·38360	·51430	·64640	·77990	·91478	1·05100	*
41	39·56	0·0	·12605	·25340	·38210	·51220	·64367	·77647	·91057	1·04597	1·18267
					Solid Ogival-headed Projectiles (two diameters).						
4	38·56	0·0	·12655	·25461	·38414	·51510	·64746	·78119	·91626	1·05264	1·19030
37	38·48	0·0	·12756	·25652	·38683	·51844	·65130	*	*	*	*
42	38·47	0·0	·12302	·24768	·37397	·50188	·63140	·76252	·89523	1·02952	1·16538
					Hollow Ogival-headed Projectiles (one diameter).						
14	21·78	0·0	·10010	·20276	·30795	·41565	·52585	·63855	·75374	·87140	·99150
16	21·81	0·0	·09850	·19926	·30247	·40824	·51662	·62762	·74124	·85748	·97634
18	21·81	0·0	·09930	·20114	·30552	·41244	·52189	·63386	·74834	·86532	·98479
20	21·83	0·0	·09900	·20072	·30505	·41190	·52120	·63290	·74699	·86346	·98230
22	21·81	0·0	·09892	·20019	·30382	·40983	·51825	·62912	·74248	·85837	·97683
24	21·83	0·0	·09953	·20157	·30613	·41322	·52285	·63503	·74977	·86708	·98697
26	21·81	0·0	·09975	·20205	·30687	·41418	·52395	·63615	·75075	·86772	·98703
28	21·83	0·0	·09900	·20048	·30444	·41088	·51981	·63123	·74514	·86154	·98043
30	21·81	0·0	·09947	·20147	·30600	·41306	·52265	·63477	·74942	·86660	·98631
32	21·81	0·0	·10379	·20989	·31833	·42915	·54240	·65814	·77644	·89738	1·02105
					Hollow Ogival-headed Projectiles (two diameters).						
15	21·92	0·0	·09934	·20123	·30562	·41247	·52175	·63344	·74753	·86402	*
19	21·94	0·0	·09829	·19913	·30257	·40866	·51745	·62899	*	*	*
21	21·89	0·0	·09951	·20143	·30575	·41246	·52155	·63301	·74683	·86300	·98151
23	21·89	0·0	·09857	·19949	·30277	·40842	·51645	·62687	·73969	·85492	*
25	21·97	0·0	·09921	·20072	·30453	·41064	·51905	·62976	·74277	·85808	·97569
27	21·95	0·0	·09906	·20045	·30416	·41018	·51850	·62911	·74201	·85720	·97468
29	21·97	0·0	·09890	·20025	·30401	·41014	·51861	·62939	·74246	·85780	·97539
31	21·91	0·0	·09928	·20075	·30448	·41053	·51895	·62978	·74305	·85878	·97698
33	21·94	0·0	·10171	·20569	·31200	·42070	·53185	·64550	·76169	·88045	*

Report dated Oct. 23, 1886.

41. Hemispherical Head.

	$v=$	1160 *f. s.*	1150 *f. s.*	1140 *f. s.*	1130 *f. s.*	1120 *f. s.*	1110 *f. s.*	1100 *f. s.*
Round 1	$K_v=$	147·3	145·8	144·2	142·7	141·2	139·5	137·9
5	$K_v=$	*	*	*	*	*	118·7	118·7
13	$K_v=$	120·0	121·2	122·4	123·5	124·7	125·9	127·1
34	$K_v=$	127·0	128·6	130·3	131·9	133·6	135·4	137·1
43	$K_v=$	135·9	137·0	138·0	139·0	140·0	141·1	*
Mean	$K_v=$	132·6	133·2	133·7	134·3	134·9	132·1	130·2

42. Hemispheroidal Head.

	$v=$	1160 *f. s.*	1150 *f. s.*	1140 *f. s.*	1130 *f. s.*	1120 *f. s.*
Round 2	$K_v=$	101·4	105·3	109·4	113·1	—
7	$K_v=$	109·1	109·1	109·1	109·1	—
35	$K_v=$	100·2	101·6	103·0	104·3	105·7
40	$K_v=$	106·9	107·6	108·3	108·8	108·8
Mean	$K_v=$	104·4	105·9	107·5	108·8	107·3

43. Ogival Head (one diameter) Solid.

	$v=$	1160 *f. s.*	1150 *f. s.*	1140 *f. s.*	1130 *f. s.*	1120 *f. s.*	1110 *f. s.*
Round 3	$K_v=$	*	*	141·0	141·0	141·0	141·0
36	$K_v=$	112·1	111·3	111·3	111·3	109·9	*
41	$K_v=$	111·5	109·8	107·2	104·8	103·6	103·6
Mean	$K_v=$	111·8	110·6	119·8	119·0	118·2	122·3

44. Ogival Head (two diameters) Solid.

	$v=$	1160 *f. s.*	1150 *f. s.*	1140 *f. s.*	1130 *f. s.*
Round 4	$K_v=$	113·0	110·7	108·7	106·7
37	$K_v=$	105·2	102·0	98·6	*
42	$K_v=$	124·1	123·6	123·0	122·5
Mean	$K_v=$	114·1	112·1	110·1	114·6

Report dated Oct. 23, 1866.

45. Ogival Head (one diameter) Hollow.

Round	$v=$	1460 *f. s.*	1440 *f. s.*	1420 *f. s.*	1400 *f. s.*	1380 *f. s.*	1360 *f. s.*	1340 *f. s.*	1320 *f. s.*	1300 *f. s.*
14	$K_v=$	*	110·9	110·4	110·0	109·7	109·7	109·6	109·3	108·7
16	$K_v=$	109·2	111·9	113·5	114·7	115·0	115·1	115·1	115·1	115·1
18	$K_v=$	*	111·6	111·6	111·3	111·1	110·8	110·5	110·2	109·9
20	$K_v=$	*	113·0	110·8	108·9	107·3	105·7	105·3	105·0	104·7
22	$K_v=$	103·8	104·4	105·0	105·9	107·0	108·1	109·3	110·5	111·7
24	$K_v=$	*	111·0	111·2	111·5	111·8	112·1	112·3	112·6	112·9
26	$K_v=$	*	110·4	109·6	108·8	108·0	107·1	106·3	105·3	104·4
28	$K_v=$	108·9	108·9	109·0	109·3	109·4	109·4	109·4	109·4	109·4
30	$K_v=$	111·0	111·0	111·0	111·0	111·0	111·0	111·0	111·0	111·0
32	$K_v=$	*	*	*	102·5	103·6	104·9	106·4	108·2	110·2
Mean	$K_v=$	108·2	110·3	110·2	109·4	109·4	109·4	109·5	109·7	109·8

46. Ogival Head (two diameters) Hollow.

Round	$v=$	1460 *f. s.*	1440 *f. s.*	1420 *f. s.*	1400 *f. s.*	1380 *f. s.*	1360 *f. s.*	1340 *f. s.*	1320 *f. s.*
15	$K_v=$	*	109·5	108·5	107·7	106·9	106·4	106·0	*
21	$K_v=$	*	105·7	105·4	105·1	104·9	104·6	104·3	104·0
23	$K_v=$	104·2	104·5	104·7	105·0	105·3	105·6	105·9	*
25	$K_v=$	101·8	101·8	101·8	101·8	101·8	101·8	101·8	101·8
27	$K_v=$	102·6	102·3	102·0	101·7	101·4	101·3	*	*
29	$K_v=$	106·5	105·5	104·5	103·7	102·8	102·0	101·4	100·7
31	$K_v=$	99·9	101·6	103·1	104·5	105·7	106·7	107·7	108·3
33	$K_v=$	*	*	103·6	105·2	107·0	108·7	110·1	111·4
Mean	$K_v=$	103·0	104·4	104·2	104·3	104·5	104·6	105·3	105·2

47. Afterwards an extended series of experiments was authorised to be made at Shoeburyness by the use of my chronograph, which were carried out in 1867, 68. The M. L. guns employed were 3, 5, 7 and 9 inches in calibre; and the projectiles were 2·92, 4·92, 6·92 and 8·92 inches in diameter, their heads being all struck with a radius of one diameter and a half. Their lengths were generally two and a half times the calibres of the guns from which they were fired. Both hollow and solid or cored shot were provided for each gun. The charge of powder was varied in order

to obtain as great a variation in the velocity of the shot as possible. The maximum velocity of 1700 f. s. was at that time considered ample for all practical purposes. The firing was continued till five good rounds were obtained with each charge. The 3, 7 and 9-inch guns were service guns, and to complete the series a bronze gun was bored out to 5 inches and rifled, but it only gave a few good rounds with low charges before it failed. Afterwards a condemned Armstrong B. L. gun was converted into a 5-inch M. L. rifled gun. This imparted a remarkable degree of steadiness to the projectiles, as was shown by the lowness of its coefficients of resistance, and by the great number of records it gave for the rounds fired.

48. Further experiments were carried out with elongated projectiles, in 1878, 9 and again in 1880. The particulars of these three sets of experiments made with ogival-headed shot are here given together, in order to combine all the values of K obtained for each velocity. Rounds 1—240 were fired on thirteen days from Oct. 7, 1867 to May 21, 1868, which were reported July 23, 1868[1] (84/B/1941). Rounds 412—482 were fired on fourteen days from Sept. 13, 1878 to March 12, 1879 which were reported July 8, 1879[2] (84/B/2853); and rounds 483—502 on three days March 8—10, 1880, which were reported Aug. 13, 1880[3] (84/B/2909).

49. Experiments were also carried out by firing both hollow and solid spherical projectiles from the 3, 5, 7 and 9-inch guns on twelve days from May 6 to Nov. 5, 1868. The Report of these experiments was dated, Feb. 13, 1869[4]. The screens were 150 feet apart, except in the few cases noted.

50. The coefficients of resistance were originally reduced for a density of the air such that one cubic foot of air weighed 530·6 grains. But since 1879 the standard density of air has been taken to be that which corresponds to a temperature of 62° Fah., and a height of 30 inches of the Barometer, which give the weight of a cubic foot of dry air 534·22 grains. All the English coefficients have now been adapted to this density.

51. As these experiments are now concluded I have carefully revised all the rounds already published, expressing time to *five* places of decimals of a second—not because time can be really

[1] Reports, &c. 1865—1870, pp. 18—54, and pp. 123—152.

[2] Report, &c., Part II., 1879. [3] Final Report, 1880.

[4] Reports, &c. 1865—1870, pp. 55—122.

measured with such extreme accuracy—but in order to obtain from each round consistent values of v and K_v. Thus the reader has placed before him the evidence for the values of K finally adopted. When each group of values of K for a given velocity consisted of numerous experimental determinations of K, I have endeavoured to include all *irregular* values of K as far as possible in taking the means. But in the few cases where I have felt obliged to exclude any experimental value of K, it has been marked (*).

52. In each case I have been careful to specify here not the date on which any experiment was made—but the date of the Report of my results to Government, which would always be found to be a day or two prior to the date of the official stamp affixed to all documents of this kind when they are received. As the dates of each round have already been given in published Reports, they need not be here repeated, for in all cases of question of priority, the date required is the day when the statement in its definite form left the hands of the experimenter. For so long as any experimenter's results remain in his own possession they are liable to be corrected or modified by him as circumstances may seem to require.

With a view to afford the Secretary of State full and reliable information of the precise value of the results obtained, the Committee, who superintended the experiments with my chronograph, 1867, 8, suggested that their report should be "referred to "mathematicians of eminence, such as the Astronomer Royal, "Professor Adams, Director of the Cambridge Observatory, or "Professor Stokes, Secretary to the Royal Society[1]." After considerable delay the referees sent in a most valuable report, in which they reviewed most of the recent chronoscopes and modes of conducting ballistic experiments. This report was printed[2] in full, but at the time no further notice was taken of it. Shortly afterwards I retired from Her Majesty's Service, but some years after this, being invited to lend my chronograph and complete my experiments, I readily agreed to do so.

[1] Reports, &c. 1870, p. 26.

[2] Ib. pp. 155—161, and Captain Ingalls's Ballistic Machines, p. 25.

Report dated July 23, 1868.

Times at which the Projectiles passed the Screens.

53. (1) 3-inch Gun. Solid Ogival-headed Projectiles.

$w = 12$ lbs.; $d = 2{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
1	0″·0	·12457	·25125	·38005	·51098	·64405	·77927	·91665	1·05620	1·19793
2	0·0	·12244	·24659	·37241	·49986	·62890	·75949	·89160	1·02521	1·16031
3	0·0	·12335	·24866	·37597	·50530	·63665	·77001	·90536	1·04267	1·18190
4	0·0	·12244	·24645	·37208	·49938	·62841	·75923	·89190	1·02648	*
5	0·0	·12279	·24702	·37279	·50017	·62920	*	*	*	*
49	0·0	·14400	·28909	·43528	·58258	·73100	·88054	1·03120	1·18298	1·33588
50	0·0	·14570	·29244	·44032	·58943	·73986	·89168	1·04495	1·19972	1·35603
52	0·0	·14356	·28847	·43470	·58221	·73097	·88095	1·03213	1·18449	*
53	0·0	·14657	·29447	·44375	·59445	·74660	·90022	1·05532	1·21190	*
54	0·0	·14502	·29124	·43867	·58733	·73725	·88847	1·04104	*	*
55	0·0	·19273	·38696	·58267	·77985	·97850	1·17862	*	*	*
56	0·0	·19347	·38832	·58456	·78221	·98129	*	*	*	*
57	0·0	·19139	·38406	·57804	·77336	·97005	1·16814	1·36767	1·56868	*
59	0·0	·18913	·37983	·57213	·76607	·96168	1·15900	*	*	*
60	0·0	·19077	·38294	·57656	·77167	·96831	1·16651	*	*	*
135	0·0	·19074	·38299	·57677	·77210	*	*	*	*	*
137	0·0	·18694	·37528	·56506	·75632	·94910	1·14344	1·33937	1·53692	*
138	0·0	·19341	·38840	·58497	·78312	·98285	1·18416	*	*	*

54. Hollow Ogival-headed Projectiles. $w = 9$ lbs.; $d = 2{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
6	0·0	·11395	·23077	·35052	·47329	·59920	*	*	*	*
7	0·0	·10900	·22005	·33325	·44870	·56649	·68669	·80935	·93450	*
9	0·0	·11318	·22877	·34680	·46730	·59030	*	*	*	*
10	0·0	·11193	·22634	·34325	·46269	·58469	·70928	·83649	*	*
11	0·0	·10996	·22243	·33744	·45502	·57520	·69801	*	*	*
12	0·0	·11051	·22339	·33872	·45657	·57701	·70008	·82580	*	*
124	0·0	·11114	·22470	·34070	·45916	·58009	·70350	·82940	·95779	1·08867
126	0·0	·10865	·21978	·33337	·44941	·56790	·68885	·81228	·93822	1·06671
13	0·0	·13064	·26382	·39959	·53799	·67905	·82279	*	*	*
14	0·0	·13340	·26865	·40581	·54493	·68604	·82916	·97430	*	*
15	0·0	·13244	·26731	·40478	·54496	·68790	*	*	*	*
16	0·0	·13037	·26267	·39693	·53318	·67146	·81181	·95426	1·09882	1·24549
17	0·0	·12765	·25754	·38970	·52416	·66095	·80010	·94164	*	*
18	0·0	·12958	·26119	·39484	·53055	·66834	·80822	·95020	*	*
19	0·0	·12421	·25088	·38001	·51160	*	*	*	*	*
26	0·0	·16784	·33701	·50751	·67935	·85254	1·02709	*	*	*
27	0·0	·17203	·34500	·51895	·69391	·86990	*	*	*	*
28	0·0	·16971	·34072	·51304	·68668	·86165	1·03796	1·21563	1·39468	*
29	0·0	·17109	·34351	·51728	·69243	·86900	*	*	*	*
30	0·0	·17130	·34391	·51787	·69323	·87005	*	*	*	*
31	0·0	·17187	·34505	·51955	·69538	·87255	*	*	*	*
32	0·0	·17115	·34351	·51713	·69205	·86830	1·04590	*	*	*

55. Hollow Ogival-headed Projectiles. $w = 6$ lbs.; $d = 2{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
39	0″·0	·09467	·19281	·29443	·39954	·50815	*	*	*	*
40	0·0	·09415	·19169	·29259	·39683	·50440	·61531	·72958	·84724	·96833
41	0·0	·09567	·19458	·29676	·40225	·51108	·62327	·73885	·85784	*
43	0·0	·09795	·19931	·30408	·41227	·52388	·63892	·75741	·87936	1·00479
44	0·0	·09300	·18929	·28892	·39193	·49837	·60828	·72171	·83870	·95930
127	0·0	·09902	·20169	·30797	·41784	·53130	·64837	·76909	*	*
129	0·0	·09863	·20054	·30573	*	*	*	*	*	*
130	0·0	·09733	·19809	·30228	·40990	·52096	·63547	·75345	·87492	·99990
131	0·0	·10219	·20779	·31682	·42931	·54529	·66480	·78787	·91454	*
132	0·0	·09830	·19992	·30492	·41334	·52520	·64050	·75924	·88143	1·00709
133	0·0	·09855	·20078	·30669	·41628	·52956	·64654	·76722	·89160	1·01968
134	0·0	·10249	·20883	·31902	·43307	·55099	·67280	·79852	*	*
33	0·0	·11131	·22678	·34643	·47029	.59840	*	*	*	*
34	0·0	·11298	·22889	·34780	·46978	*	*	*	*	*
35	0·0	·11027	·22396	·34107	·46159	·58551	·71282	·84351	·97757	1·11499
36	0·0	·11075	·22503	·34289	·46438	·58955	·71843	·85103	*	*
37	0·0	·10979	·22325	·34038	·46118	·58566	·71383	*	*	*
38	0·0	·11181	·22709	·34587	·46817	·59402	·72344	·85645	·99308	1·13335
20	0·0	·14753	·29677	·44773	·60043	·75489	·91114	1·06921	1·22912	1·39089
21	0·0	·14718	·29620	·44706	·59977	·75434	·91078	1·06910	*	*
23	0·0	·14240	·28724	·43456	·58439	·73676	·89170	*	*	*
24	0·0	·14572	·29374	·44406	·59668	·75160	·90883	1·06839	1·23031	1·39462
25	0·0	·14554	·29318	·44294	·59483	·74887	·90507	1·06345	1·22404	1·38688

56. (2) 5-inch Gun. Cored Ogival-headed Projectiles. $w = 47{\cdot}68$ lbs.; $d = 4{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
164	0·0	·10995	·22112	·33352	·44716	·56205	·67820	·79561	·91428	1·03421
165	0·0	·11234	·22573	·34019	·45574	·57240	·69019	·80912	·92920	1·05044
166	0·0	·11320	·22745	·34275	·45910	·57650	·69496	·81449	·93510	1·05680
167	0·0	·11194	·22500	·33919	·45451	·57097	·68858	·80735	·92728	1·04838
168	0·0	·11401	·22910	·34528	·46255	·58092	·70039	·82097	·94266	1·06547
139	0·0	·12284	·24682	·37194	·49820	·62561	·75418	·88391	1·01480	1·14685
140	0·0	·12201	·24519	·36957	·49518	·62204	·75016	·87955	1·01021	1·14214
141	0·0	·12192	·24511	·36959	·49537	·62247	·75090	·88066	1·01176	1·14422
142	0·0	·12175	·24462	·36863	·49380	·62013	·74762	·87627	1·00609	1·13710
143	0·0	·12216	·24566	·37049	·49664	·62410	·75286	·88292	1·01428	1·14694
169	0·0	·13336	·26776	·40324	·53984	·67759	·81651	·95661	1·09790	*
170	0·0	·13124	·26371	·39741	·53234	·66850	·80589	·94450	1·08432	1·22534
171	0·0	·13040	·26189	·39447	·52814	·66291	·79879	·93579	1·07392	1·21319
172	0·0	·12979	·26075	·39289	·52621	·66071	·79639	·93326	1·07132	1·21057
173	0·0	·13082	·26275	·39580	·52998	·66529	·80174	·93933	1·07806	1·21793
159	0·0	·14329	·28743	·43242	·57826	·72495	·87248	1·02085	1·17005	1·32007
160	0·0	·14541	·29168	·43881	·58680	·73565	·88536	1·03593	1·18736	1·33965
161	0·0	·14629	·29339	·44131	·59004	·73958	·88994	1·04112	1·19311	1·34592
162	0·0	·14762	·29625	·44590	·59658	·74830	·90107	1·05490	1·20980	*
163	0·0	·14520	·29111	·43773	·58506	·73310	·88185	1·03131	1·18149	1·33239

57. Hollow Ogival-headed Projectiles. $w = 23{\cdot}84$ lbs.; $d = 4{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
144	0″·0	·08737	·17643	·26718	·35962	*	*	*	*	*
145	0·0	·08586	·17377	·26374	·35578	·44991	·54614	·64449	·74498	·84763
146	0·0	·08542	·17284	·26227	·35372	·44720	·54272	·64028	·73988	·84152
147	0·0	·08694	·17594	·26701	·36015	·45537	·55267	·65206	·75354	·85711
154	0·0	·09137	·18491	·28063	·37854	·47865	·58097	·68552	·79234	·90147
155	0·0	·09160	·18504	·28042	·37784	·47740	·57920	·68334	·78992	·89904
156	0·0	·09133	·18455	·27974	·37698	·47635	·57793	·68180	·78805	·89677
157	0·0	·09239	·18654	·28257	·38060	·48074	·58310	·68779	·79491	·90456
158	0·0	·09160	·18533	·28121	·37926	·47950	·58195	·68663	·79356	·90276
148	0·0	·10885	·22009	·33372	·44975	·56819	·68905	·81235	·93811	1·06635
149	0·0	·10793	·21842	·33149	·44715	·56540	·68624	·80967	·93568	1·06426
150	0·0	·10935	·22099	·33493	·45118	·56975	·69065	·81389	·93949	1·06747
151	0·0	·10933	·22101	·33507	·45154	·57045	·69183	*	*	*
152	0·0	·10899	·22041	·33427	·45058	·56935	·69058	·81427	·94042	1·06903
153	0·0	·10729	·21691	·32886	·44314	·55975	·67869	·79997	·92359	1·04955
61	0·0	·11780	·23863	·36251	·48946	·61950	·75265	*	*	*
62	0·0	·11556	·23401	·35535	·47958	*	*	*	*	*
63	0·0	·11612	·23473	·35587	·47958	*	*	*	*	*
64	0·0	·11673	·23596	·35767	·48184	·60845	·73748	·86893	1·00280	1·13909
66	0·0	·11617	·23467	·35551	·47870	·60426	·73222	·86262	·99551	1·13095
67	0·0	·11661	·23567	·35715	·48103	·60731	·73600	·86711	1·00067	1·13672
174	0·0	·12618	·25463	·38533	·51826	·65341	·79076	·93030	1·07202	1·21592
175	0·0	·13780	·27780	·41990	·56402	·71011	·85813	1·00806	*	*
176	0·0	·13321	·26840	·40557	·54471	·68581	·82886	·97385	*	*
177	0·0	·16960	·34051	·51273	·68627	·86115	1·03740	1·21506	*	*
178	0·0	·16103	·32342	·48719	·65236	·81895	·98698	1·15647	*	*

58. (3) 7-inch Gun. Cored Ogival-headed Projectiles.
$w = 123{\cdot}125$ lbs.; $d = 6{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
97	0·0	·11185	·22465	·33841	·45314	·56885	·68555	·80326	·92200	*
98	0·0	·11054	·22205	·33455	·44806	·56260	·67819	·79485	·91260	1·03146
99	0·0	·10916	·21922	·33019	·44207	·55487	·66860	·78328	·89893	1·01557
100	0·0	·10940	·21974	·33104	·44332	·55660	·67091	·78627	·90270	1·02022
101	0·0	·11467	·23039	·34718	·46506	·58405	*	*	*	*
86	0·0	·12305	·24691	·37160	·49714	·62355	*	*	*	*
87	0·0	·12232	·24564	·36996	·49528	·62160	·74892	·87724	1·00657	1·13692
88	0·0	·12380	·24863	·37451	·50146	·62949	·75860	·88878	1·02002	1·15230
89	0·0	·12331	·24758	·37281	*	*	*	*	*	*
91	0·0	·12591	·25275	·38049	·50910	·63856	·76885	·89995	1·03185	1·16454
92	0·0	·12330	·24739	·37227	·49794	*	*	*	*	*
93	0·0	·12515	·25157	·37924	·50814	·63825	·76955	·90202	1·03563	1·17035
103	0·0	·15018	·30102	·45251	·60464	·75740	·91078	1·06477	1·21936	1·37454
104	0·0	·15138	·30335	·45590	·60902	*	*	*	*	*
105	0·0	·14941	·29960	·45055	·60224	·75465	·90776	1·06156	1·21604	*

59. Hollow Ogival-headed Projectiles. $w = 61 \cdot 156$ lbs.; $d = 6 \cdot 92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
113	0″·0	·09199	·18565	·28101	·37810	·47694	·57754	·67991	·78406	*
114	0·0	·09303	·18782	·28440	·38280	·48305	·58518	·68921	·79516	*
115	0·0	·09147	·18474	·27984	·37680	·47565	*	*	*	*
116	0·0	·09333	·18834	·28503	·38339	·48341	·58508	·68839	·79333	·89989
117	0·0	·09193	·18552	·28079	·37776	·47646	·57692	*	*	*
94	0·0	·11213	·22604	·34177	·45936	·57885	·70028	·82368	·94907	1·07646
96	0·0	·10988	·22187	·33599	·45226	·57068	·69125	*	*	*
110	0·0	·11100	·22421	·33966	·45738	·57740	*	*	*	*
111	0·0	·11138	·22486	·34046	·45820	·57810	·70018	·82446	*	*
112	0·0	·11192	·22573	·34149	·45924	·57900	·70079	·82463	·95054	1·07854
121	0·0	·17071	·34313	·51725	·69306	·87055	1·04971	*	*	*
122	0·0	·17178	·34522	·52031	·69704	·87540	1·05539	1·23701	1·42026	*

60. (4) 9-inch Gun. Cored Ogival-headed Projectiles.
$w = 250$ lbs.; $d = 8 \cdot 92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
218	0·0	·11523	·23124	·34803	·46560	·58395	·70308	·82300	·94371	1·06521
219	0 0	·11549	·23166	·34854	·46616	·58455	·70375	·82381	·94478	*
220	0·0	·11590	·23271	·35041	·46898	·58839	·70861	·82961	·95136	1·07383
221	0·0	·11496	·23076	·34740	·46488	·58320	·70236	·82237	·94323	1·06494
228	0·0	·11674	·23441	·35298	·47243	·59274	·71389	·83587	·95867	*
229	0·0	·11876	·23812	·35808	·47864	·59980	·72156	·84392	·96688	*
239	0·0	·11872	·23804	·35798	·47856	·59979	·72169	·84428	·96758	1·09161
240	0·0	·12060	·24185	·36375	·48630	·60951	·73339	·85795	·98321	1·10920
208	0·0	·12522	·25121	·37796	·50546	·63370	·76267	·89237	1·02280	1·15396
209	0·0	·12464	·24999	·37605	·50282	·63029	·75846	·88732	1·01687	*
210	0·0	·12407	·24882	·37425	·50035	·62713	·75459	·88273	*	*
211	0·0	·12517	·25125	·37823	·50609	·63481	·76436	·89471	1·02582	*
212	0·0	·12560	·25181	·37864	·50609	·63417	·76289	·89227	1·02232	1·15306
232	0·0	·13428	·26942	·40541	·54224	·67990	·81838	·95768	*	*
233	0·0	·13390	·26887	·40491	·54202	*	*	*	*	*
234	0·0	·13401	·26855	·40366	·53938	·67575	·81281	·95060	1·08916	*
235	0·0	·13516	·27084	·40704	·54377	·68104	·81886	·95725	1·09623	*
236	0·0	·13362	·26803	·40323	·53922	·67601	·81362	·95208	1·09142	1·23168
237	0·0	·13448	·26977	·40587	·54277	·68046	·81894	·95821	1·09827	1·23912
238	0·0	·13412	·26899	·40462	·54103	·67824	·81627	·95514	1·09487	1·23548
222	0·0	·15369	·30781	·46237	·61738	·77285	·92879	1·08521	1·24212	*
223	0·0	·15327	·30717	·46170	·61686	·77266	·92911	1·08622	1·24401	1·40250
224	0·0	·15287	·30635	·46047	·61526	·77074	·92693	1·08385	1·24152	1·39996
225	0·0	·15486	·31049	·46688	·62403	·78194	·94061	1·10003	*	*
226	0·0	·15304	·30667	·46091	·61579	·77133	·92755	*	*	*
227	0·0	·15539	·31135	·46789	·62502	·78277	·94118	1·10030	1·26019	*

61. Hollow Ogival-headed Projectiles. $w = 125$ lbs.; $d = 8 \cdot 92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
230	0·0	·14203	·28707	·43512	*	*	*	*	*	*
213	0·0	·17402	·35024	·52866	*	*	*	*	*	*
214	0·0	·17620	·35453	·53499	·71757	·90226	*	*	*	*

Report dated Feb. 13, 1869.

Times at which the Projectiles passed the Screens.

62. (1) 3-inch Gun. Solid Spherical Projectiles.

$w = 3{\cdot}316$ lbs.; $d = 2{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
284	0″·0	·07184	·14980	·23389	·32410	*	*	*	*	*
285	0·0	·07294	·15215	·23806	·33110	·43170	·54028	·65725	·78302	·91800
286	0·0	·07062	·14698	·22963	·31912	·41601	·52086	·63423	·75668	*
287	0·0	·07170	·14937	·23347	·32446	·42281	·50900	·62352	·74687	·87956
288	0·0	·07592	·15801	·24677	·34270	·44631	·55810	·67858	·80825	·94762
290	0·0	·08388	·17483	·27329	·37970	·49448	·61798	·75048	·89219	1·04325
291	0·0	·07691	·16011	·25008	·34730	·45225	·56540	·68722	·81818	·95874
292	0·0	·08361	·17437	·27270	·37897	·49350	·61655	·74833	·88900	1·03867
293	0·0	·07932	·16572	·25929	·36011	*	*	*	*	*
294	0·0	·07821	·16311	·25510	·35459	·46200	·57776	·70231	*	*
295	0·0	·08312	·17320	·27070	·37608	·48979	·61228	·74400	·88540	*
296	0·0	·08225	·17166	·26863	·37355	·48681	·60879	·73986	*	*
297	0·0	·08183	·17096	·26771	·37240	·48535	·60688	·73731	*	*
312	0·0	·08442	·17644	·27637	·38451	·50115	·62657	·76104	·89482	*
261	0·0	·12310	·25571	·39738	·54773	·70646	·87336	*	*	*
262	0·0	·12460	·25812	·40033	·55104	·71009	·87736	1·05276	*	*
263	0·0	·12318	·25554	·39677	·54655	·70456	·87048	1·04399	*	*
264	0·0	·11669	·24255	·37732	·52076	·67266	·83284	1·00116	1·17752	1·36186
266	0·0	·12536	·25987	·40326	*	*	*	*	*	*
267	0·0	·12046	·25079	·39027	·53821	*	*	*	*	*
268	0·0	·15270	·31383	·48337	·66130	·84760	*	*	*	*
269	0·0	·13915	·28619	·44124	·60443	·77590	·95580	1·14429	*	*
270	0·0	·12822	·26517	·41085	·56526	·72840	*	*	*	*
271	0·0	·13572	·28001	·43270	·59362	·76260	·93947	1·12405	*	*
272	0·0	·14167	·29124	·44888	·61477	·78910	·97207	*	*	*
273	0·0	·13753	·28347	·43745	·59910	*	*	*	*	*

63. Hollow Spherical Projectiles. $w = 2$ lbs.; $d = 2{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
310	0·0	·07226	·15304	·24534	·35123	·47185	·60741	·75718	·91949	*
311	0·0	·07149	·15327	·24658	·35305	·47391	·60958	·75964	·92318	*
281	0·0	·09060	·19443	·31194	·44356	·58970	·75075	*	*	*
282	0·0	·11458	·24393	·38742	·54442	·71429	·89638	1·09004	*	*
283	0·0	·09013	·19353	·31024	*	*	*	*	*	*
299	0·0	·07816	·16795	·27023	·38586	·51570	*	*	*	*
300	0·0	·09936	·21333	·34157	·48373	·63945	·80837	·99012	*	*
301	0·0	·07729	·16520	·26556	·37963	·50811	·65115	·80837	·97887	1·16124
277	0·0	·11958	·25372	·40171	·56286	·73650	*	*	*	*
279	0·0	·11549	·24592	·39048	·54836	*	*	*	*	*
302	0·0	·09346	·20110	·32296	·45908	·60950	·77426	*	*	*
303	0·0	·09221	·19822	·31857	·45347	·60278	·76597	·94214	1·13004	1·32808
304	0·0	·09274	·19968	·32098	·45680	·60730	*	*	*	*
274	0·0	·17092	·35481	·55005	·75502	*	*	*	*	*
275	0·0	·18342	·37606	·57907	·79360	*	*	*	*	*
308	0·0	·12551	·26565	·41962	·58662	*	*	*	*	*
309	0·0	·12540	·26580	·42044	·58855	·76933	·96193	*	*	*

64. (2) 5-inch Gun. Solid Spherical Projectiles.

$w = 15{\cdot}789$ lbs.; $d = 4{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
407	0″·0	·07452	·15252	·23432	·32024	*	*	*	*	*
408	0·0	·07814	·16030	·24664	·33732	·43251	·53238	·63710	·74683	·86173
409	0·0	·06918	·14195	·21847	·29884	·38314	·47147	·56399	·66098	·76291
410	0·0	·06822	·14003	·21558	·29502	·37849	·46613	·55807	·65444	·75537
411	0·0	·06927	·14206	·21851	·29876	·38296	·47126	·56381	*	*
315	0·0	·07980	·16385	·25227	·34518	·44269	·54491	·65195	*	*
316	0·0	·08212	·16834	·25878	·35359	·45295	·55707	·66618	·78053	·90039
317	0·0	·07982	·16372	·25188	·34449	·44174	·54382	·65091	·76318	·88079
318	0·0	·09417	·19278	·29583	·40332	·51525	*	*	*	*
380	0·0	·07848	·16069	·24689	·33734	·43229	·53199	·63669	·74663	·86205
381	0·0	·08017	·16423	·25235	·34471	·44149	·54287	·64902	·76011	·87630
382	0·0	·09119	·18674	·28690	·39191	·50200	·61739	·73829	·86491	·99746
383	0·0	·09078	·18561	·28508	·38978	·50030	*	*	*	*
385	0·0	·08680	·17754	·27247	·37186	·47600	·58519	·69974	·81996	·94616
386	0·0	·08817	·18031	·27688	·37830	·48492	·59700	·71467	·83789	·96641
387	0·0	·08788	·18011	·27687	·37834	·48470	·59613	·71280	*	*
388	0·0	·09636	·19724	·30278	·41312	·52840	·64875	*	*	*
389	0·0	·09625	·19685	·30209	·41226	·52763	·64846	·77500	·90750	*
390	0·0	·09533	·19495	·29942	·40929	·52510	*	*	*	*
392	0·0	·09583	·19598	·30086	·41090	·52655	*	*	*	*

65. Hollow Spherical Projectiles. $w = 7{\cdot}894$ lbs.; $d = 4{\cdot}92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
394	0·0	·06508	·13692	·21622	·30367	·39995	·50573	·62167	·74842	*
395	0·0	·06332	·13282	·20930	·29356	·38639	·48857	·60087	·72405	*
396	0·0	·06266	·13165	·20774	·29161	·38425	·48616	·59815	·72095	·85529
397	0·0	·06355	·13354	·21061	·29540	*	*	*	*	*
398	0·0	·06172	·13141	·20910	·29482	·38858	·49038	·60022	·71810	*
399	0·0	·06278	·13209	·20863	·29310	·38619	·48858	·60094	·72393	·85820
400	0·0	·06521	·13732	·21692	·30461	·40100	·50671	·62237	*	*
401	0·0	·06236	·13127	·20741	·29145	·38405	·48587	·59756	·71978	·85319
320	0·0	·07762	·16322	·25746	·36100	·47451	·59867	·73416	·88166	*
321	0·0	·07680	·16159	·25499	·35762	·47010	*	*	*	*
322	0·0	·07769	·16288	·25666	·36012	*	*	*	*	*
323	0·0	·07574	·15963	·25226	·35421	·46605	·58835	·72168	·86661	*
324	0·0	·07616	·16036	·25322	·35537	·46745	·59011	*	*	*
325	0·0	·07681	·16120	·25398	·35595	·46790	·59061	*	*	*
402	0·0	·07657	·16082	·25355	·35556	·46765	·59062	*	*	*
403	0·0	·07870	·16534	·26065	·36537	·48026	·60608	·74359	·89355	*
404	0·0	·07564	·15895	·25065	·35146	·46211	·58333	*	*	*
405	0·0	·07655	·16075	·25359	·35607	·46920	*	*	*	*
406	0·0	·07597	·15955	·25154	·35273	·46390	·58582	*	*	*

66. (3) 7-inch Gun. Solid Spherical Projectiles.

$w = 44·094$ lbs.; $d = 6·92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
326	0″·0	·08417	·17110	·26107	·35436	·45125	·55202	*	*	*
327	0·0	·08409	·17124	·26154	·35507	·45190	·55209	·65571	·76282	·87349
329	0·0	·08673	·17631	·26889	·36463	·46370	·56627	·67250	·78255	*
330	0·0	·08412	·17125	·26144	·35475	·45124	·55097	·65400	·76039	*
341	0·0	·08431	·17168	·26221	·35600	·45315	·55376	·65793	·76577	·87739
373	0·0	·08552	·17406	·26571	·36055	·45866	·56011	·66498	·77336	·88534
379	0·0	·08547	·17415	·26607	·36127	·45979	·56168	·66699	·77577	·88808
331	0·0	·09281	·18900	·28863	·39175	·49840	·60862	*	*	*
332	0·0	·09285	·18910	·28875	·39180	·49826	·60813	*	*	*
334	0·0	·09353	·19016	·28999	·39313	·49969	·60979	*	*	*
336	0·0	·09343	·19010	·29011	·39356	·50054	·61115	·72548	·84361	·96561
342	0·0	·09241	·18816	·28731	·38992	·49606	·60581	*	*	*
343	0·0	·09226	·18806	·28740	·39029	·49672	·60668	·72016	*	*
337	0·0	·11053	·22480	·34285	·46473	·59049	·72017	·85381	·99145	1·13312
338	0·0	·12033	·24458	·37276	·50487	·64090	*	*	*	*
339	0·0	·12482	·25382	·38689	·52393	·66484	·80953	·95790	1·10985	*
344	0·0	·11235	·22853	·34860	·47262	·60065	·73275	·86897	1·00935	*
345	0·0	·11343	·23054	·35148	·47639	·60541	·73867	*	*	*
353	0·0	·14380	·29083	·44122	·59509	·75255	·91370	1·07863	1·24741	1·42010
354	0·0	·14585	·29504	·44768	·60387	·76370	·92725	1·09459	*	*
355	0·0	·16081	·32433	·49151	·66289	·83861	1·01838	1·20151	*	*
356	0·0	·15464	·31210	·47309	·63802	·80700	·97985	1·15610	*	*
357	0·0	·14087	·28567	·43445	·58726	·74415	*	*	*	*

67. Hollow Spherical Projectiles. $w = 22·047$ lbs.; $d = 6·92$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
346	0·0	·08645	·17875	·27741	·38293	·49580	*	*	*	*
347	0·0	·08485	·17569	·27296	·37711	·48860	*	*	*	*
349	0·0	·08534	·17644	·27388	·37826	·49021	·61040	*	*	*
350	0·0	·08473	·17545	·27255	·37641	·48740	·60589	·73225	·86685	*
351	0·0	·08780	·18186	·28255	·39024	·50530	·62810	·75901	*	*
352	0·0	·08530	·17698	·27528	·38043	·49267	*	*	*	*
365	0·0	·08881	·18402	·28599	·39508	·51165	*	*	*	*
366	0·0	·08716	·18045	·28034	·38724	·50150	·62343	·75332	·89146	*
367	0·0	·09480	·19626	·30476	·42068	·54440	·67630	*	*	*
368	0·0	·09536	·19750	·30669	·42322	·54740	*	*	*	*
369	0·0	·09506	·19684	·30553	·42153	·54545	·67811	·82054	·97398	*
370	0·0	·09525	·19717	·30618	·42262	·54675	·67875	·81871	·96663	*
371	0·0	·09468	·19600	·30421	·41957	·54236	·67287	·81140	*	*
372	0·0	·09444	·19524	·30299	·41814	·54102	·67185	·81077	·95785	*
374	0·0	·09247	·19173	·29801	·41153	·53249	·66109	·79752	·94196	1·09458
375	0·0	·08807	·18226	·28287	·39020	·50456	·62626	*	*	*
376	0·0	·09333	·19295	·29928	·41275	·53379	·66282	·80025	·94648	*
377	0·0	·09692	·20102	·31252	·43164	·55859	·69357	·83677	*	*
378	0·0	·08971	·18601	·28919	·39954	·51736	·64295	·77662	·91868	*
360	0·0	·10942	·22612	·35036	·48240	·62250	*	*	*	*
363	0·0	·10800	·22382	·34751	·47905	·61835	·76523	·91942	1·08056	*
364	0·0	·09995	·20620	·31931	·43981	·56820	*	*	*	*

68. (4) 9-inch Gun. Solid Spherical Projectiles.
$w = 94·5$ lbs.; $d = 8·888$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
253	0″·0	·07805	·15818	·24043	·32485	·41148	·50035	·59148	·68489	·78059
255	0·0	·07719	·15653	·23802	·32167	·40748	·49545	·58557	·67783	·77222
257	0·0	·08017	·16218	·24617	·33227	·42059	·51124	·60432	·69993	·79817
258	0·0	·08021	·16231	·24640	·33258	·42095	·51161	·60466	·70019	·79829
259	0·0	·07961	·16131	·24510	·33098	·41898	·50913	·60148	·69608	·79300
260	0·0	·08015	·16206	·24591	·33187	·42010	·51074	·60392	·69974	·79827
204	0·0	·08885	·18018	·27404	·37047	·46949	·57112	·67538	·78228	·89182
205	0·0	·08673	·17575	·26707	·36071	·45669	·55503	*	*	*
206	0·0	·08907	·18050	·27454	·37097	·46989	·57133	·67531	·78183	·89090
241	0·0	·08801	·17841	·27121	·36640	·46399	·56397	·66633	·77107	*
242	0·0	·09022	·18284	·27792	·37552	·47569	·57849	·68396	·79216	·90313
243	0·0	·08914	·18060	·27443	·37068	·46940	·57064	·67445	·78087	·88995
244	0·0	·08950	·18130	·27546	·37204	·47110	·57270	·67690	·78376	·89334
245	0·0	·08779	·17783	·27021	·36500	·46227	·56209	·66454	·76970	·87765
179	0·0	·09729	·19714	·29957	·40459	·51221	·62244	·73527	·85069	·96870
180	0·0	·09712	·19691	·29937	·40448	·51221	·62254	·73547	·85100	·96915
181	0·0	·09799	·19849	·30155	·40723	·51560	·62673	·74070	·85756	·97733
182	0·0	·09831	·19918	·30267	·40884	·51775	·62943	·74388	·86113	·98121
183	0·0	·09608	·19459	·29559	·39915	·50534	·61423	·72589	·84038	*
184	0·0	·12202	·24689	·37462	·50523	·63875	·77521	·91464	1·05706	1·20248
185	0·0	·13617	·27488	·41614	·55996	·70634	·85528	1·00678	1·16083	*
187	0·0	·12312	·24946	·37894	·51148	·64700	·78541	·92662	1·07053	*
189	0·0	·13121	·26522	·40204	·54168	·68415	·82945	·97758	1·12855	1·28236
190	0·0	·12599	·25478	·38638	·52080	·65805	·79814	*	*	*
191	0·0	·12830	·25946	·39350	·53044	·67030	·81310	·95887	1·10763	*
192	0·0	·13156	·26577	·40265	·54222	·68449	·82947	·97718	1·12765	1·28092

69. Hollow Spherical Projectiles. $w = 67·5$ lbs.; $d = 8·886$ inches.

No. of Round	1 Sc.	2 Screen.	3 Screen.	4 Screen.	5 Screen.	6 Screen.	7 Screen.	8 Screen.	9 Screen.	10 Screen.
248	0·0	·07497	·15262	·23306	·31651	·40310	·49296	·58620	·68291	·78316
249	0·0	·07793	·15888	·24290	·33004	·42035	·51389	·61071	·71086	*
251	0·0	·07555	·15415	·23580	·32051	·40828	·49911	·59300	·68996	*
246	0·0	·08794	·17919	·27388	·37214	·47410	·57990	·68969	·80362	·92185
247	0·0	·08728	·17768	·27135	·36845	·46914	·57357	·68189	·79424	·91076
252	0·0	·08777	·17891	·27354	·37177	·47371	·57946	·68911	·80273	·92037
254	0·0	·08648	·17643	·26987	·36684	·46740	·57162	·67957	·79132	·90694
256	0·0	·08798	·17933	·27407	·37226	·47400	·57944	·68877	·80222	*
193	0·0	·10513	·21416	·32710	·44396	·56475	·68948	·81816	·95080	1·08741
194	0·0	·10431	·21256	·32476	·44092	·56107	·68524	·81345	·94572	1·08206
195	0·0	·10401	·21186	·32359	·43926	·55895	·68274	·81069	·94284	1·07921
196	0·0	·10788	·21978	·33572	·45573	·57985	·70812	·84057	·97722	1·11808
197	0·0	·11108	·22583	·34427	·46641	·59225	·72178	·85500	·99193	1·13261
198	0·0	·14273	·28919	·43942	·59345	·75130	·91298	1·07850	1·24787	*
199	0·0	·14482	·29332	·44551	·60140	·76101	·92437	1·09151	1·26247	*
200	0·0	·14483	·29322	·44521	·60084	·76013	·92308	1·08969	1·25998	1·43399
201	0·0	·12838	·26021	·39549	*	*	*	*	*	*
202	0·0	·14670	·29679	·45033	·60741	·76815	·93266	1·10103	1·27333	1·44961
203	0·0	·14453	·29263	·44436	·59977	·75890	·92178	1·08843	1·25888	1·43317

Report dated July 8, 1879.

70. Times at which the Elongated Projectiles passed the Screens.

Form of Head	w lbs.	d inch.	No. of Round	Screens 150 feet apart. 1	2	3	4	5	6	7	8	9	10	11	12
Ogival	70·0	6·0	461	0″·0	·07710	·15520	·23425	·31421	·39505	·47675	·55930	·64270	*	*	*
,,	70·0	,,	462	0·0	·07752	·15608	·23570	·31640	·39820	·48110	·56510	·65019	·73634	·82353	·91174
,,	70·0	,,	463	0·0	·07724	·15539	·23446	·31447	·39542	·47731	·56014	·64392	·72866	·81437	·90106
Flat	70·0	,,	464	0·0	·07873	·15948	·24225	·32704	·41384	·50265	·59347	·68630	·78114	*	*
,,	70·0	,,	465	0·0	·07909	·16024	·24346	·32877	·41619	·50575	·59749	·69144	·78763	·88608	·98682
,,	70·0	,,	466	0·0	·07934	·16061	·24394	·32940	·41702	·50680	·59871	·69271	·78874	·88675	·98669
Hemi-	70·0	,,	467	0·0	·07918	·15963	·24135	·32435	·40863	·49419	·58103	·66915	·75855	·84923	·94119
spherical	70·0	,,	468	0·0	·07942	·15978	·24116	·32364	·40731	·49227	·57860	·66636	·75559	·84632	·93858
,,	70·0	,,	469	0·0	·07847	·15829	·23947	·32201	·40592	·49120	·57785	·66587	·75526	·84601	·93812
Ogival	70·0	,,	470	0·0	·08439	·16987	·25641	·34398	·43256	·52212	·61264	·70408	·79641	·88960	·98362
,,	70·0	,,	471	0·0	·08491	·17061	·25713	·34450	·43276	*	*	*	*	*	*
,,	70·0	,,	472	0·0	·08554	·17205	·25955	·34806	·43761	·52821	·61986	·71256	·80631	·90111	*
,,	50·0	,,	473	0·0	·06987	·14104	·21348	·28717	·36208	·43818	·51546	·59390	·67347	·75414	*
,,	50·0	,,	474	0·0	·06904	·13925	·21063	·28318	·35691	·43183	·50794	·58524	·66374	·74345	*
,,	50·0	,,	475	0·0	·06918	·13951	·21102	·28375	·35773	·43297	·50944	·58711	·66594	·74590	*
,,	50·0	,,	476	0·0	·06950	·14012	·21187	·28476	·35879	·43396	·51028	·58775	·66636	·74611	*
,,	50·0	,,	477	0·0	·06877	·13869	·20977	·28202	·35545	·43006	·50585	·58280	·66090	·74013	*
,,	50·0	,,	478	0·0	·06679	·13466	·20362	·27368	·34483	·41707	·49039	·56478	*	*	*
,,	50·0	,,	479	0·0	·06659	·13427	·20305	·27292	·34388	·41593	·48907	·56331	·63865	·71509	·79263
,,	50·0	,,	480	0·0	·06596	·13299	·20110	·27029	·34056	·41192	·48436	·55789	·63250	·70820	*
,,	50·0	,,	481	0·0	·06660	·13429	·20306	·27290	·34380	·41575	·48874	·56276	·63780	·71385	·79090
,,	50·0	,,	482	0·0	·06565	·13244	·20038	·26947	·33969	·41102	·48344	·55692	·63144	·70699	·78356

71. Times at which the Ogival-headed Projectiles passed the Screens.

w lbs.	d inches.	No. of Round	Screens 75 feet apart.															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
6·50	2·97	412	0″·0	·07144	·14382	·21709	·29120	·36609	·44170	·51799	·59492	·67242	·75041	·82884	·90766	·98683	1·06629	1·14598
6·50	,,	413	0·0	·06957	·13986	·21085	·28250	·35478	·42765	·50107	·57501	·64946	·72442	·79988	·87584	·95229	1·02922	1·10662
6·50	,,	414	0·0	·07174	·14420	·21735	·29117	·36562	·44067	·51628	·59241	·66903	·74614	·82374	·90184	·98045	1·05958	*
6·50	,,	415	0·0	·07813	·15690	·23629	·31628	·39684	·47797	·55968	·64200	·72496	·80857	·89283	·97775	1·06333	1·14957	*
6·56	,,	416	0·0	·07598	·15226	·22888	·30586	·38322	·46101	·53928	·61804	·69729	·77705	·85734	·93819	1·01963	1·10170	1·18443
6·50	,,	417	0·0	·07588	·15226	·22914	·30652	·38440	·46279	·54171	·62118	·70121	·78183	·86307	·94496	1·02754	1·11086	1·19497
6·44	,,	418	0·0	·07882	·15824	·23830	·31904	·40050	·48269	·56561	·64924	·73355	·81850	·90405	*	*	*	*
6·50	,,	419	0·0	·07763	·15570	·23421	·31316	·39256	·47242	·55275	·63358	·71495	·79691	·87949	·96269	1·04651	1·13095	*
6·47	,,	421	0·0	·08304	·16620	·24955	·33315	·41707	·50139	·58617	·67147	·75736	·84390	·93116	1·01922	1·10815	1·19803	*
6·56	,,	422	0·0	·08175	·16421	·24737	·33122	·41574	·50090	·58665	·67293	·75968	·84683	·93430	1·02202	1·10994	1·19802	*
6·47	,,	423	0·0	·08467	·16964	·25492	·34052	·42645	·51273	·59939	·68647	·77401	·86203	·95055	1·03959	1·12917	*	*
6·66	,,	424	0·0	·09667	·19397	·29190	·39046	·48964	·58944	·68986	·79086	·89240	·99449	1·09712	1·20032	1·30407	1·40838	1·51324
6·56	,,	425	0·0	·09426	·18897	·28416	·37986	·47610	·57292	·67035	·76841	·86713	·96654	1·06667	1·16754	1·26918	1·37142	1·47489
6·63	,,	426	0·0	·10255	·20569	·30942	·41374	·51866	·62419	·73034	·83715	·94468	1·05299	1·16213	1·27214	1·38307	1·49506	1·60796
6·47	,,	427	0·0	·09203	·18455	·27756	·37106	·46504	·55951	·65448	·74996	·84597	·94252	1·03961	*	*	*	*
6·63	,,	428	0·0	·09434	·18916	·28447	·38027	·47657	·57339	·67074	·76862	·86703	·96598	1·06547	1·16550	1·26607	1·36718	1·46883
6·47	,,	429	0·0	·08501	·17051	·25650	·34299	·43000	·51754	·60564	·69433	·78361	·87349	·96396	1·05502	1·14667	1·23892	*
6·47	,,	430	0·0	·08791	·17629	·26514	·35445	·44422	·53445	·62514	·71629	·80789	·89995	·99246	1·08543	1·17887	1·27279	1·36720

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
6·63	,,	432	0·0	·10486	·21016	·31592	·42217	·52894	·63626	·74416	·85266	*	*	*	*	*	*	*
6·56	,,	433	0·0	·10572	·21219	·31940	·42736	·53607	·64553	·75574	·86669	·97837	1·09078	1·20392	1·31778	1·43236	1·54766	*
6·63	,,	434	0·0	·10213	·20500	·30861	·41295	·51801	·62378	·73025	·83741	·94525	1·05377	1·16297	1·27285	1·38340	1·49462	*
6·56	,,	435	0·0	·10238	·20558	·30959	·41440	·52001	·62642	·73363	·84164	·95045	1·06006	1·17047	1·28167	1·39366	1·50644	1·62001
6·63	,,	436	0·0	·10754	·21580	·32478	·43449	·54495	·65619	·76822	·88104	·99463	1·10896	1·22402	1·33979	1·45625	*	*
6·63	,,	437	0·0	·10758	·21594	·32508	·43500	·54570	·65718	·76943	·88245	·99624	1·11080	1·22612	1·34219	1·45901	1·57658	*
6·63	,,	438	0·0	·12421	·24961	·37614	·50374	·63235	·76192	·89239	1·02371	1·15583	1·28871	1·42231	1·55658	1·69147	*	*
6·31	,,	439	0·0	·12901	·25878	·38931	·52060	·65266	·78549	·91909	1·05346	1·18862	1·32458	1·46136	1·59899	1·73749	1·87687	2·01713
6·34	,,	440	0·0	·12506	·25080	·37724	·50441	·63234	·76105	·89056	1·02089	1·15205	1·28404	1·41687	1·55054	1·68506	1·82044	1·95669
6·31	,,	441	0·0	·12681	·25439	·38274	·51186	·64174	·77238	·90377	1·03590	1·16876	1·30235	1·43667	1·57172	1·70749	1·84399	1·98121
6·53	,,	442	0·0	·12999	·26090	·39273	·52548	·65914	·79371	·92919	1·06559	1·20292	1·34117	1·48034	1·62043	1·76144	1·90338	2·04625
6·41	,,	443	0·0	·09762	·19593	·29493	·39462	·49498	·59599	·69763	0·79990	0·90280	1·00633	1·11049	1·21529	1.32073	1·42682	1·53357
6·41	,,	444	0·0	·09584	·19224	·28921	·38675	·48487	·58356	·68282	0·78265	0·88305	0·98403	1·08559	1·18772	1·29042	1·39369	1·49754
6·34	,,	445	0·0	·10086	·20228	·30425	·40677	·50985	·61350	·71773	0·82254	0·92794	1·03392	1·14049	1·24765	1·35539	1·46371	1·57261
6·41	,,	446	0·0	·09505	·19066	·28682	·38353	·48079	·57861	·67699	0·77593	0·87544	0·97552	1·07617	1·17739	1·27918	1·38153	1·48443
6·41	,,	447	0·0	·10224	·20510	·30858	·41268	·51740	·62274	·72871	0·83532	0·94257	1·05047	1·15903	1·26825	1·37814	1·48871	1·59996
6·31	,,	448	0·0	·12423	·24911	·37465	·50086	·62775	·75534	·88365	1·01269	1·14246	1·27297	1·40423	1·53625	1·66905	1·80265	1·93707
70·0	6·27	449	0·0	·12250	·24511	·36785	·49074	·61381	·73709	·86064	0·98452	1·10879	1·23351	1·35874	1·48453	1·61091	1·73788	1·86544
70·0	,,	450	0·0	·12356	·24746	·37170	·49628	·62120	·74648	·87214	0·99824	1·12484	1·25199	1·37972	1·50803	1·63690	1·76631	1·89624
70·0	,,	451	0·0	·12300	·24641	·37022	·49443	·61904	·74404	·86942	0·99517	1·12128	1·24774	1·37454	1·50167	1·62911	1·75684	1·88484
70·0	,,	452	0·0	·13557	·27148	·40773	·54433	·68129	·81861	·95630	1·09473	1·23281	1·37163	1·51083	1·65041	1·79038	1·93074	2·07150
70·0	,,	453	0·0	·13749	·27530	·41344	·55193	·69079	·83003	·96967	1·10971	1·25016	1·39103	1·53232	1·67402	1·81613	1·95864	2·10153
70·0	,,	454	0·0	·15676	·31410	·47202	·63052	·78960	·94926	1·10948	1·27025	1·43157	1·59344	1·75586	1·91883	2·08233	2·24633	2·41078
70·0	,,	455	0·0	·16863	·33788	·50777	·67832	·84954	1·02143	1·19400	1·36726	1·54123	1·71594	1·89141	2·06766	2·24471	*	*
70·0	,,	456	0·0	·15658	·31356	·47094	·62872	·78690	0·94548	1·10445	1·26379	1·42349	1·58354	1·74395	1·90473	2·06590	2·22748	2·38947
70·0	,,	457	0·0	·16916	·33871	·50866	·67902	·84980	1·02101	1·19264	1·36469	1·53716	1·71005	1·88336	2·05709	2·23124	*	*
70·0	,,	458	0·0	·15475	·31012	·46611	·62271	·77990	0·93767	1·09600	1·25487	1·41426	1·57416	1·73455	1·89542	2·05675	2·21853	*
70·0	,,	459	0·0	·16965	·33977	·51036	·68142	·85295	1·02494	1·19740	1·37032	1·54371	1·71757	1·89189	2·06666	2·24188	*	*

Report dated Aug. 31, 1880.

72. Times at which the Ogival-headed Projectiles passed the Screens.

			Screens 150 feet apart.											
w lbs.	d inches.	No of Round	1	2	3	4	5	6	7	8	9	10	11	12
80·0	8·0	483	0″·0	·05389	·10871	·16447	·22118	·27884	·33746	·39705	·45761	·51914	·58164	*
,,	,,	484	0·0	·05338	·10779	·16322	·21967	*	*	*	*	*	*	*
,,	,,	485	0·0	·05379	·10893	·16536	·22302	·28185	·34179	·40278	·46478	·52777	·59173	·65665
,,	,,	486	0·0	·05355	·10805	·16351	·21993	·27731	·33565	·39494	·45518	·51636	·57848	·64154
,,	,,	487	0·0	·05347	·10791	·16331	·21967	·27699	·33528	·39455	·45481	·51607	·57835	·64167
,,	,,	488	0·0	·05410	·10915	·16515	·22211	·28003	·33890	·39871	·45945	·52112	·58372	·64726
,,	,,	489	0·0	·05782	·11653	·17614	·23664	·29803	*	*	*	*	*	*
,,	,,	490	0·0	·06367	·12848	·19443	·26151	·32973	·39908	·46957	·54121	·61401	*	*
,,	,,	491	0·0	·06156	·12448	·18875	·25436	·32128	·38948	·45894	·52965	·60161	·67482	·74929
,,	,,	492	0·0	·06186	·12487	·18903	·25434	·32079	·38836	·45703	·52679	·59763	·66954	·74251
,,	,,	493	0·0	·06111	·12353	·18726	·25231	·31868	·38637	·45537	·52567	·59726	·67013	·74427
,,	,,	494	0·0	·06083	·12278	·18586	·25008	·31545	·38198	·44969	·51860	·58873	·66010	·73273
,,	,,	495	0·0	·06287	·12665	·19138	·25709	·32382	·39158	·46040	·53030	·60129	·67338	*
,,	,,	496	0·0	·05358	·10812	·16362	·22008	·27751	·33590	·39525	·45557	·51688	·57918	·64248
,,	,,	497	0·0	·06511	·13158	·19942	·26864	·33925	·41125	·48465	·55945	·63564	·71322	*
,,	,,	498	0·0	·06232	·12591	·19078	·25695	·32444	·39326	·46341	·53489	·60770	·68185	*
,,	,,	499	0·0	·06296	·12718	·19266	·25941	·32742	·39669	·46721	·53897	·61197	·68621	*
,,	,,	500	0·0	·06432	·12998	·19697	·26527	·33487	·40578	·47801	·55156	·62645	·70269	*
,,	,,	501	0·0	·06540	·13187	·19941	·26802	·33770	·40845	·48028	·55320	·62722	·70234	·77856
,,	,,	502	0·0	·07029	·14171	·21427	·28798	·36285	·43890	·51615	·59460	·67425	·75509	·83713

73. Report dated February 13, 1869.

720 *f. s.*

Round	K_v
275	119·2

740 *f. s.*

Round	K_v
275	113·2

760 *f. s.*

Round	K_v
274	105·8
275	107·2
Mean	106·5

780 *f. s.*

Round	K_v
Mean	106·8

800 *f. s.*

Round	K_v
274	120·9
282	120·3
303	113·4
Mean	118·2

820 *f. s.*

Round	K_v
Mean	128·2

840 *f. s.*

Round	K_v
264	137·4
268	144·1
269	145·9
271	133·5
274	133·3
282	125·3
303	124·8
309	127·2
355	160·2*
Mean	133·9

860 *f. s.*

Round	K_v
Mean	136·4

880 *f. s.*

Round	K_v
200	139·1
202	147·9
203	143·7
262	139·9
263	132·7
264	138·6
268	144·4
269	143·3
271	136·6
272	145·3
282	129·8
300	133·1
301	125·1
303	132·9
309	132·7
353	157·4
355	173·1*
356	158·4
Mean	140·0

900 *f. s.*

Round	K_v
Mean	141·7

920 *f. s.*

Round	K_v
198	144·3
199	141·6
200	137·5
202	142·3
203	141·4
261	138·8
262	141·3
263	137·7
264	140·3
268	144·7
269	141·1
270	150·1
271	139·3
272	142·4
277	131·9
282	133·7
300	135·3
301	137·6
303	138·6
309	137·3
353	152·2
354	150·7
355	126·6
356	160·0
Mean	141·1

940 *f. s.*

Round	K_v
Mean	141·0

960 *f. s.*

Round	K_v
198	143·6
199	139·5
200	137·2
202	134·2
203	139·5
261	141·7
262	143·0
263	142·1
264	142·2
269	139·2
270	150·1
271	141·7
272	139·8
273	133·2
277	135·6
282	137·1
300	137·1
301	142·6
302	147·2
303	142·8
308	136·5
309	141·3
311	139·8
353	145·3
354	144·9
356	118·1*
363	141·5
Mean	140·7

980 *f. s.*

Round	K_v
Mean	141·7

1000 *f. s.*

Round	K_v
185	131·6
189	149·4
192	145·9
198	142·2
199	138·7
200	135·2
202	128·5
203	136·6
261	145·2
262	144·9
263	146·0
264	144·5
269	137·4

1000 *f. s.* *continued.*

Round	K_v
270	150·1
271	143·9
272	137·5
273	138·2
277	138·9
279	138·9
281	153·7
282	140·2
300	138·9
301	146·2
302	147·0
303	145·6
308	140·3
309	144·8
310	138·8
311	144·1
339	142·1
353	137·1
354	137·7
357	161·9
363	147·7
374	163·1
Mean	142·9

1020 *f. s.*

Round	K_v
Mean	144·0

1040 *f. s.*

Round	K_v
185	131·6
189	148·8
191	156·2
192	142·7
261	149·0
262	146·9
263	149·6
264	146·8
269	135·8
270	150·1
271	145·9
273	142·7
277	141·9
279	142·5
281	152·1
282	142·9
290	158·5
292	153·1
300	140·4
301	148·2

1040 *f. s.* *continued.*

Round	K_v
302	146·8
303	147·6
308	143·7
309	148·0
310	145·2
311	147·6
339	148·5
357	159·0
363	151·9
369	210·4*
374	160·7
Mean	147·5

1060 *f. s.*

Round	K_v
Mean	150·5

1080 *f. s.*

Round	K_v
184	153·0
185	130·9
187	145·5
189	148·4
191	153·8
192	141·6
196	158·5
261	152·9
262	149·0
263	152·8
264	149·1
266	152·8
267	152·1
270	150·1
277	144·7
279	145·7
281	150·6
282	145·4
290	157·1
292	151·9
300	141·9
301	149·4
302	146·7
303	148·8
304	150·2
308	146·8
309	150·9
310	149·3
311	150·2
312	158·3
320	171·2

1080 *f. s.* *continued.*

Round	K_v
323	167·2
337	159·7
339	153·6
363	154·8
369	197·5*
370	158·4
372	161·7
374	158·5
376	172·3
377	163·2
403	171·8
Mean	152·9

1100 *f. s.*

Round	K_v
Mean	154·0

1120 *f. s.*

Round	K_v
184	150·6
187	153·4
189	147·6
190	148·5
191	152·0
192	139·8
193	149·1
194	153·0
195	158·6
196	157·8
197	139·1
261	156·9
262	151·1
263	155·5
264	151·4
266	155·2
267	158·7
270	150·1
277	147·4
279	148·6
281	149·2
282	147·7
288	164·7
290	155·5
291	162·0
292	150·7
295	162·7
300	143·2
301	149·9
302	146·5
303	149·5

Round	K_v
1120 f. s. continued.	
304	149·6
308	149·6
309	153·5
310	152·1
311	152·0
312	156·0
320	167·0
323	163·6
337	158·0
338	155·5
339	158·6
344	162·5
360	160·9
363	156·7
366	163·9
369	186·1
370	158·0
371	159·0
372	160·5
374	156·3
376	167·7
377	160·9
378	163·8
403	167·4
Mean	155·4
1140 f. s.	
Mean	155·3
1160 f. s.	
184	148·2
187	159·6
190	147·6
193	148·8
194	152·5
195	157·6
196	156·9
197	138·7
261	160·7
262	153·2
263	158·7
264	153·6
267	164·7
277	149·8
279	151·3
281	147·8
282	149·8
285	157·6
288	160·3
290	153·7

Round	K_v
1160 f. s. continued.	
291	158·2
292	149·3
295	159·0
300	144·4
301	149·9
302	146·4
303	149·6
304	149·1
310	153·8
311	152·6
312	153·7
320	163·0
323	160·2
337	156·2
338	155·9
339	163·2
344	160·1
345	165·2
350	161·6
360	157·8
363	157·8
366	160·7
369	176·0
370	156·9
371	155·5
372	159·1
374	154·0
376	163·1
377	158·8
378	160·4
382	171·3
389	172·1
403	163·2
Mean	156·4
1180 f. s.	
Mean	156·2
1200 f. s.	
184	146·9
187	165·2
193	148·3
194	151·7
195	156·0
196	155·6
197	139·0
264	155·7
279	153·7

Round	K_v
1200 f. s. continued.	
281	146·5
282	151·8
285	154·3
287	157·8
288	156·3
290	151·7
291	154·5
292	147·7
295	155·5
296	153·7
297	151·0
300	145·5
301	149·2
302	146·3
303	149·5
304	148·6
310	154·2
311	152·3
312	151·5
320	159·3
323	157·0
337	154·4
338	155·8
344	157·6
345	159·6
350	157·8
351	158·4
360	155·0
363	158·4
366	157·6
367	160·1
369	167·0
370	155·3
371	152·2
372	157·2
374	151·9
376	158·7
377	156·7
378	157·0
382	166·8
386	155·2
389	166·9
396	160·1
399	156·5
401	155·9
403	159·1
Mean	154·9
1220 f. s.	
Mean	154·2

Round	K_v
1240 f. s.	
193	147·8
194	150·8
195	153·6
196	154·1
197	139·1
281	145·2
285	151·0
287	153·9
288	152·7
290	149·5
291	150·9
292	146·0
295	152·0
296	150·9
297	148·5
299	144·9
300	146·5
301	148·3
302	146·2
303	149·2
304	148·2
310	154·3
311	151·6
312	149·4
320	155·7
323	153·9
337	152·4
344	155·2
345	154·0
350	154·0
351	154·7
360	152·2
363	158·5
364	154·5
366	154·6
367	156·3
369	159·2
370	153·3
371	149·1
372	155·0
374	149·8
376	154·5
377	154·6
378	153·9
382	162·5
385	169·7
386	160·5
389	161·8
394	152·6
396	156·4
399	153·2
401	152·5
403	155·3
Mean	152·7

Round	K_v
1260 f. s.	
Mean	151·4
1280 f. s.	
181	149·1
182	144·7
193	147·5
194	149·8
195	150·8
196	152·7
197	138·8
281	144·0
285	148·1
286	155·5
287	150·2
288	149·1
290	147·1
291	147·5
292	144·2
294	147·1
295	148·7
296	148·1
297	146·0
299	142·5
300	147·4
301	146·8
302	146·1
303	148·4
304	147·8
310	153·2
311	150·1
312	147·4
320	152·2
323	150·9
324	152·5
325	155·1
336	151·4
337	150·5
344	153·0
345	148·3
350	150·5
351	151·2
360	149·6
363	158·2
364	149·4
366	151·8
367	152·6
368	149·4
369	152·6
370	151·0
371	146·1
372	152·3
374	147·8
375	145·1
376	150·4

Round	K_v
1280 f. s. continued.	
377	152·5
378	150·9
382	158·4
385	163·8
386	162·1
388	146·2
389	156·8
394	149·3
395	153·4
396	152·7
399	150·0
401	149·2
402	153·6
403	151·5
Mean	150·1
1300 f. s.	
Mean	148·6
1320 f. s.	
179	133·3
180	133·7
181	147·0
182	142·7
193	147·2
194	148·8
195	148·0
196	151·8
197	138·2
246	162·1
247	159·6
252	153·9
254	149·1
281	142·9
285	145·1
286	151·7
287	146·7
288	145·5
290	144·6
291	144·2
292	142·4
294	144·0
295	145·5
296	145·5
297	143·8
299	140·2
300	148·3
301	145·2
302	146·0
303	147·6

Round	K_v
1320 *f. s.* *continued.*	
304	147·4
310	152·2
311	148·6
312	145·4
316	153·9
317	152·9
320	148·9
323	148·2
324	149·5
325	151·4
336	148·6
337	148·9
349	158·5
350	147·0
351	147·8
360	147·0
363	157·7
364	144·3
366	148·9
367	149·0
368	146·5
369	146·8
370	148·4
371	143·4
372	149·4
374	145·9
375	142·1
376	146·3
377	150·4
378	148·1
381	147·5
382	154·4
385	158·0
386	161·7
387	151·3
388	143·6
389	151·7
394	146·2
395	149·8
396	149·3
398	113·6
399	146·8
401	146·0
402	149·9
403	147·9
404	147·3
406	149·2
Mean	147·6
1340 *f. s.*	
Mean	146·8

Round	K_v
1360 *f. s.*	
179	134·0
180	133·7
181	142·7
182	142·5
183	142·4
193	146·9
194	148·5
195	146·1
196	151·2
204	138·9
246	157·3
247	155·3
252	152·0
254	146·8
256	156·4
281	141·8
285	142·3
286	148·0
287	143·2
288	142·0
290	142·1
291	141·0
292	140·6
294	141·0
295	142·5
296	142·9
297	141·6
299	138·1
300	149·1
301	143·3
302	145·9
303	146·6
304	147·0
310	150·3
311	146·1
312	143·5
316	149·0
317	150·0
320	145·7
323	145·5
324	146·4
325	147·8
336	145·5
343	139·0
349	152·8
350	143·7
351	144·5
364	139·2
365	146·2
366	146·1
367	145·6
368	143·8
369	142·4
370	145·6
371	140·9
372	146·0

Round	K_v
1360 *f. s.* *continued.*	
374	144·0
375	139·3
376	142·4
377	148·5
378	145·4
380	155·4
381	144·5
382	150·4
385	152·5
386	159·1
387	148·0
388	140·8
389	146·8
390	165·1
392	152·8
394	143·2
395	146·4
396	146·0
398	113·6
399	143·8
400	140·4
401	143·0
402	146·3
403	144·4
404	143·9
406	145·7
408	144·4
Mean	145·2
1380 *f. s.*	
Mean	143·5
1400 *f. s.*	
179	133·9
180	134·4
181	138·5
182	140·6
183	138·3
193	146·6
194	148·2
195	144·8
204	138·9
206	134·0
242	147·4
243	142·7
244	145·4
246	152·8
247	151·0
252	149·7
254	144·5

Round	K_v
1400 *f. s.* *continued.*	
256	149·0
281	140·8
283	137·9
285	139·5
286	144·4
287	140·0
288	138·8
290	139·5
291	137·9
292	138·6
294	138·2
295	139·6
296	140·4
297	139·5
299	136·0
300	149·9
301	141·2
302	145·8
303	145·5
304	146·6
310	148·2
311	143·7
312	141·7
316	144·8
317	147·1
318	128·1
320	142·6
321	141·7
323	142·9
324	143·4
325	144·3
327	139·8
329	149·9
331	141·0
332	135·3
334	138·8
336	142·2
341	146·2
342	141·8
343	139·4
346	142·4
347	144·1
349	147·5
350	140·5
351	141·3
352	138·9
364	134·1
365	143·1
366	143·1
367	142·3
368	141·3
369	138·9
370	142·7
371	138·7
372	142·4

Round	K_v
1400 *f. s.* *continued.*	
373	138·5
374	142·2
375	136·5
376	138·6
377	146·6
378	142·8
379	136·5
380	151·4
381	141·5
382	146·4
383	167·1
385	147·0
386	155·5
387	144·8
388	138·2
389	141·7
390	156·4
392	145·3
394	140·3
395	143·0
396	142·8
398	113·6
399	140·8
400	137·5
401	140·0
402	142·8
403	141·0
404	140·7
405	149·9
406	142·3
408	141·6
Mean	142·3
1420 *f. s.*	
Mean	140·7
1440 *f. s.*	
179	133·3
180	136·1
181	134·5
182	137·0
183	134·3
204	138·6
206	133·6
242	144·6
243	139·9
244	141·8
245	146·6
246	148·3
247	146·6

Round	K_v
1440 *f. s.* *continued.*	
252	147·1
254	142·3
256	143·3
281	139·7
283	137·8
285	136·9
286	140·9
287	136·9
288	135·7
290	137·0
291	134·9
292	136·5
294	135·5
295	136·8
296	138·0
297	137·5
299	134·0
301	138·8
302	145·7
303	144·3
304	146·3
310	145·8
311	140·7
312	139·8
315	138·7
316	140·6
317	144·1
318	128·1
320	139·6
321	138·9
323	140·4
324	140·7
325	140·9
327	137·7
329	144·8
330	132·9
331	139·7
332	135·3
334	134·8
336	139·0
341	142·6
342	139·1
343	139·7
346	138·4
347	140·3
349	142·6
350	137·5
351	138·2
352	136·9
364	128·9
365	140·1
366	140·3
367	139·1
368	139·0
369	136·2

1440 f. s. continued.

Round	K_v
370	139·6
371	136·5
372	138·3
373	135·5
374	140·4
375	133·7
376	134·9
377	144·8
378	140·3
379	134·8
380	147·4
381	138·5
382	142·5
383	158·3
385	141·7
386	150·9
387	141·7
388	135·7
389	136·5
390	147·4
392	137·9
394	137·5
395	139·8
396	139·7
398	113·6
399	138·0
400	134·8
401	137·2
402	139·4
403	137·8
404	137·6
405	145·8
406	139·0
408	138·9
Mean	139·2

1460 f. s.

Mean 137·8

1480 f. s.

Round	K_v
179	132·7
180	137·2
181	131·2
182	133·6
183	130·3
204	137·7
206	133·0
241	128·3
242	141·6
243	137·3

1480 f. s. continued.

Round	K_v
244	138·2
245	142·1
246	144·3
247	142·3
252	144·3
254	140·2
256	138·9
281	138·8
283	137·7
285	134·3
286	137·6
287	133·9
288	132·6
290	134·4
291	132·0
292	134·4
294	133·0
295	134·1
296	135·7
297	135·6
299	132·0
301	136·4
302	145·6
303	143·0
304	146·0
310	143·0
311	137·5
312	138·1
315	136·8
316	136·8
317	141·2
318	128·1
320	136·8
321	136·3
323	138·0
324	138·0
325	137·6
327	135·6
329	139·8
330	130·9
331	138·5
332	134·9
334	131·0
336	136·1
341	139·3
342	136·9
343	140·1
346	134·4
347	136·7
349	137·8
350	134·5
351	135·3
352	135·0
365	137·2
366	137·2

1480 f. s. continued.

Round	K_v
367	136·0
368	136·8
369	134·2
370	136·2
371	134·4
372	133·8
373	132·7
374	138·6
375	131·2
376	131·4
377	143·2
378	138·1
379	133·2
380	143·4
381	135·6
382	138·6
383	149·2
385	136·8
386	145·8
387	138·7
388	133·1
389	131·4
390	138·2
392	130·9
394	134·7
395	136·7
396	136·7
398	113·6
399	135·3
400	132·1
401	134·5
402	136·1
403	134·7
404	134·5
405	141·9
406	135·8
408	136·2
Mean	136·4

1500 f. s.

Mean 134·8

1520 f. s.

Round	K_v
179	131·7
180	137·3
183	126·7
204	136·6
206	131·6
241	128·8
242	138·3

1520 f. s. continued.

Round	K_v
243	134·4
244	134·8
245	137·7
246	140·5
247	138·0
252	141·4
254	138·3
256	135·3
281	137·8
283	137·6
285	131·8
286	134·3
287	131·0
288	129·6
290	131·9
291	129·1
292	132·4
294	130·5
295	131·5
296	133·5
297	133·8
299	130·2
301	133·7
310	140·1
311	134·3
312	136·4
315	135·1
316	133·3
317	138·3
318	128·1
320	134·0
321	133·7
323	135·7
324	135·3
325	134·3
326	153·7
327	133·5
329	134·7
330	128·9
331	137·0
332	134·9
334	127·5
336	133·0
341	136·3
342	135·0
343	139·8
346	130·5
347	133·3
349	133·2
350	131·5
351	132·3
352	133·2
365	134·4
366	134·0
367	133·0

1520 f. s. continued.

Round	K_v
368	134·7
369	133·1
370	132·9
371	132·4
372	129·0
373	130·5
374	136·8
375	128·8
376	128·0
378	135·9
379	131·6
380	139·5
381	132·7
382	134·7
383	140·0
385	131·9
386	140·0
387	135·8
388	130·8
389	126·4
390	128·9
392	124·1
394	132·1
395	133·7
396	133·9
398	113·6
399	132·6
400	129·6
401	131·9
402	132·9
403	131·7
404	131·6
405	138·0
406	132·7
408	133·5
409	136·9
Mean	133·6

1540 f. s.

Mean 132·4

1560 f. s.

Round	K_v
204	135·6
205	123·7
206	130·3
241	129·3
242	135·6
243	131·7
244	131·6
245	133·9

1560 f. s. continued.

Round	K_v
246	137·1
247	133·5
248	134·6
249	127·0
252	138·4
254	136·6
256	132·6
257	140·3
258	137·3
260	144·8
285	129·4
286	131·2
287	128·3
288	126·6
290	129·4
291	126·4
292	130·3
293	123·2
294	128·1
295	128·9
296	131·3
297	132·0
299	128·4
301	131·0
310	136·6
311	131·0
312	134·8
315	133·4
316	130·1
317	135·3
320	131·4
321	131·3
322	135·9
323	133·5
324	132·8
325	131·2
326	146·1
327	131·6
329	129·6
330	127·1
331	135·3
332	134·9
334	124·2
336	129·9
341	133·4
342	133·3
343	139·7
346	126·7
347	129·9
349	128·7
350	128·6
251	129·5
352	131·5
365	131·7
366	130·7

1560 f. s. continued.

Round	K_v
373	128·3
374	135·1
375	126·4
378	133·7
379	130·3
380	135·7
381	129·7
382	130·7
383	130·9
385	127·3
386	133·4
387	132·9
394	129·5
395	130·7
396	131·1
398	113·6
399	129·9
400	127·2
401	129·4
402	129·8
403	128·8
404	128·7
405	134·3
406	129·6
408	130·9
409	129·7
410	126·9
Mean	131·4

1580 f. s.

Mean 129·8

1600 f. s.

Round	K_v
204	134·1
205	122·6
206	129·3
241	128·9
242	132·5
243	129·0
244	128·4
245	130·2
246	133·7
247	129·2
248	132·4
249	125·5
251	118·1
252	135·5
253	123·3
254	135·3
256	131·0

1600 f. s. continued.

Round	K_v
257	135·0
258	132·7
259	121·8
260	140·8
285	127·0
286	128·1
287	125·6
288	123·8
290	126·9
291	123·7
292	128·2
293	122·7
294	125·8
295	126·4
296	129·1
297	130·3
299	126·7
301	128·1
310	133·2
311	127·7
312	133·2
315	131·7
316	127·3
317	132·5
320	128·8
321	128·9
322	131·8
323	131·3
324	130·5
325	128·2
326	138·7
327	129·8
329	124·7
330	125·4
341	130·5
346	122·9
347	126·6
349	124·3
350	125·8
351	126·9
352	129·8
365	129·1
366	127·4
373	125·9
375	124·1
378	131·6
379	129·1
380	131·9
381	126·9
382	126·8
383	121·3
385	122·9
386	126·7
387	130·2
394	127·0

1600 f. s. continued.

Round	K_v
395	127·8
396	128·3
398	113·6
399	127·4
400	124·8
401	127·0
402	126·8
403	126·0
404	126·0
405	130·6
406	126·7
408	128·4
409	124·0
410	124·9
Mean	128·1

1620 f. s.

Mean 126·7

1640 f. s.

Round	K_v
204	131·9
205	121·6
206	128·6
241	129·4
242	129·5
243	126·5
244	125·1
245	126·6
246	130·4
247	125·0
248	130·0
249	124·1
251	117·9
252	132·6
253	122·6
254	134·4
255	115·4
256	130·1
257	130·1
258	127·9
259	118·9
260	135·7
285	124·7
286	125·1
287	123·1
288	121·1
290	124·6
291	121·1
292	126·1
293	122·3

1640 f. s. continued.

Round	K_v
294	123·6
295	124·0
296	127·0
297	128·7
299	125·1
301	125·0
310	129·5
311	124·4
312	131·6
315	130·1
316	124·7
317	129·7
320	126·4
321	126·6
322	127·9
323	129·2
324	128·2
325	125·2
326	131·3
327	127·7
329	119·8
330	123·6
341	127·8
346	119·1
347	123·4
349	120·1
350	123·0
351	124·2
352	128·2
366	124·0
373	123·7
375	122·0
379	128·0
380	128·3
381	124·1
385	118·8
386	119·5
387	127·5
394	124·5
395	125·0
396	125·7
398	113·6
399	124·9
400	122·5
401	124·6
402	123·9
403	123·3
404	123·4
405	127·1
406	123·9
408	125·9
409	119·7
410	123·0
Mean	125·4

1660 f. s.

Mean 124·0

1680 f. s.

Round	K_v
205	120·8
241	128·8
245	122·1
247	121·1
248	127·3
249	122·5
251	117·9
253	121·5
254	133·9
255	115·9
257	125·2
258	122·9
259	116·2
260	129·5
285	122·4
286	122·2
287	120·6
288	118·5
290	122·4
291	118 6
292	124·0
293	121·9
294	121·6
295	121·6
296	125·1
297	127·1
299	123·5
301	121·8
310	125·4
311	121·2
312	130·1
315	128·5
316	122·5
317	127·0
320	124·0
321	124·4
322	123·9
323	127·1
324	125·8
325	122·2
326	123·8
327	125·6
329	115·3
330	121·9
341	125·2
346	115·4
347	120·4
349	115·9
350	120·3
352	126·6
373	121·4

1680 f. s. continued.

Round	K_v
379	127·0
380	124·6
381	121·4
385	114·9
394	122·1
395	122·3
396	123·1
398	113·6
399	122·5
400	120·3
401	122·2
402	121·1
403	120·6
404	120·9
405	123·7
406	121·1
408	123·6
409	116·9
410	121·1
411	119·0
Mean	122·4

1700 f. s.

Mean 121·1

1720 f. s.

Round	K_v
248	124·4
249	121·2
251	117·9
253	120·4
255	116·3
257	119·7
258	118·0
259	114·5
260	122·8
284	105·2
285	120·3
286	119·4
287	118·2
288	115·9
291	116·1
292	121·8
293	121·5
294	119·6
295	119·3
296	123·2
297	125·6
299	122·0
301	118·5
310	121·3

1720 f. s. continued.

Round	K_v
311	118·0
315	126·8
316	120·7
317	124·4
320	121·7
321	122·2
322	120·1
323	125·1
324	123·7
325	119·3
326	116·2
327	123·4
330	120·5
341	122·6
373	119·0
379	126·3
380	121·0
381	118·8
394	119·7
395	119·6
396	120·6
398	113·6
399	120·2
400	118·2
401	120·0
402	118·3
403	118·1
404	118·4
405	120·3
406	118·3
408	121·3
409	114·7
410	119·4
411	116·9
Mean	119·8

1740 f. s.

Mean 118·5

1760 f. s.

Round	K_v
248	121·3
249	120·0
251	117·9
253	118·8
255	116·4
257	114·2
258	112·9
259	113·0
260	115·1
284	105·3

1760 f. s. continued.

Round	K_v
285	118·2
286	116·6
287	115·9
288	113·4
291	113·7
293	121·1
294	117·6
299	120·5
301	115·0
310	116·8
311	115·2
315	125·3
316	119·1
317	122·0
320	119·5
321	120·1
322	116·2
323	123·2
324	121·6
325	116·5
380	117·4
381	116·3
394	117·5
395	116·9
396	118·1
398	113·6
399	118·0
400	116·1
401	117·7
402	115·5
403	115·6
404	116·0
405	116·9
406	115·6
408	119·2
409	113·0
410	117·6
411	114·9
Mean	117·0

1780 f. s.

Mean 115·2

1800 f. s.

Round	K_v
248	117·8
249	118·8
251	117·9
253	117·0
255	116·4
257	108·0

1800 f. s. continued.

Round	K_v
258	107·9
259	112·7
260	106·8
284	105·4
285	116·0
286	114·1
287	113·6
288	111·0
291	111·3
293	120·6
294	115·8
301	111·6
310	111·9
311	112·5
315	123·8
317	119·6
320	117·3
321	118·1
322	112·4
323	121·3
324	119·6
325	113·7
380	113·8
381	114·0
394	115·3
395	114·3
396	115·6
398	113·5
399	115·7
400	114·1
401	115·6
402	112·9
403	113·2
404	113·6
405	113·7
406	112·9
407	115·4
408	117·2
409	111·7
410	115·8
411	112·9
Mean	114·6

1820 f. s.

Mean 113·2

1840 f. s.

Round	K_v
248	114·3
249	117·7
251	117·7

1840 f. s. continued.

Round	K_v
253	114·8
255	116·1
257	100·9
258	103·0
259	112·7
260	97·6
284	105·4
285	114·1
286	111·5
287	111·5
288	108·6
291	109·1
294	113·9
310	107·0
311	109·8
320	115·2
321	116·1
322	108·7
323	119·4
324	117·6
325	110·9
380	110·4
394	113·1
395	111·8
396	113·3
398	113·5
399	113·5
400	112·2
401	113·4
402	110·3
404	111·3
405	110·5
406	110·3
407	111·3
408	115·2
409	110·5
410	114·0
411	110·9
Mean	111·7

1860 f. s.

Mean 111·4

1880 f. s.

Round	K_v
248	110·7
249	116·6
251	117·5
253	112·7
255	115·9
284	105·3

1880 f. s. continued.

Round	K_v
285	112·2
286	108·8
287	109·4
288	106·2
310	101·6
311	108·0
323	117·6
394	111·0
395	109·3
396	110·9
397	107·9
398	113·4
399	111·4
400	110·2
401	111 4
404	109·0
406	107·8
407	107·3
409	109 6
410	112·3
411	109·0
Mean	110·5

1900 f. s.

Mean 108·9

1920 f. s.

Round	K_v
248	107·0
251	117·5
284	105·3
285	110·3
286	106·3
287	107·3
310	96·0
311	106·1
394	108·9
395	106·9
396	108·7
397	105·9
398	113·3
399	109·3
400	108·5
401	109·4
407	103·2
409	108·7
410	110·7
411	107·2
Mean	107·8

1940 f. s.

Mean 106·8

1960 f. s.

Round	K_v
248	103·1
284	105·2
285	108·4
286	103·8
287	105·3
310	90·3
311	104·3
394	106·8
395	104·5
396	106·4
397	104·0
398	113·2
399	107·2
400	106·7
401	107·4
407	99·2
409	107·6
410	109·0
411	105·5
Mean	105·2

1980 f. s.

Mean 105·8

2000 f. s.

Round	K_v
284	105·2
286	101·4
287	103·3
394	104·8
395	102·1
396	104·2
397	102·1
398	113·2
399	105·2
400	105·0
401	105·5
409	106·3
410	107·3
411	103·9
Mean	105·0

2020 f. s.

Mean 104·2

Round	K_v
2040 f. s.	
286	98·9
394	102·8
395	99·7
396	102·0
397	100·2
398	113·1
399	103·2
400	103·3
401	103·7
409	104·8
410	105·6
411	102·3
Mean	103·3
2060 f. s.	
Mean	102·9

Round	K_v
2080 f. s.	
394	100·8
395	97·4
396	99·8
397	98·5
398	113·0
399	101·3
400	101·6
401	101·8
409	103·1
410	104·0
411	100·8
Mean	102·0
2100 f. s.	
Mean	100·0

Round	K_v
2120 f. s.	
394	99·0
395	95·1
396	97·8
397	96·7
398	113·0*
399	99·4
400	100·1
401	100·0
410	102·4
Mean	98·8
2140 f. s.	
Mean	97·9

Round	K_v
2160 f. s.	
394	97·1
395	92·8
396	95·7
397	94·9
398	112·9*
399	97·5
400	98·6
401	98·2
Mean	96·4
2180 f. s.	
Mean	95·5

Round	K_v
2200 f. s.	
395	90·7
396	93·6
397	93·2
398	112·8*
399	95·7
401	96·4
Mean	93·9
2220 f. s.	
Mean	93·0
2240 f. s.	
395	88·5
396	91·6
397	91·4

Round	K_v
2240 f. s. continued.	
398	112·7*
399	93·9
401	94·7
Mean	92·0
2260 f. s.	
Mean	91·3
2280 f. s.	
396	89·7
398	112·6*
401	93·0
Mean	91·4

74. Density of the Air when the following Rounds were fired.

No. of Rounds	Density	No. of Rounds	Density	No. of Rounds	Density
1— 15	1·002	225—240	0·989	431—438	1·025
16— 41	1·011	241—260	0·986	439—444	1·039
42— 60	1·025	261—287	1·005	445—448	1·031
61— 68	1·045	288—312	1·015	449—452	1·053
69— 84	1·045	313—325	1·005	453—460	1·054
85— 89	1·028	326—340	1·032	461	1·030
90—102	1·020	341—352	1·037	462	1·034
103—117	1·027	353—364	1·016	463	1·042
118—138	1·037	365—379	1·030	464—466	1·051
139—147	1·007	380—391	1·002	467—477	1·039
148—178	1·001	392—411	1·026	478—482	1·014
179—187	1·034	412—414	1·011	483—488	1·046
188—206	1·011	415—423	1·008	489—499	1·037
207—224	0·986	424—430	1·020	500—502	1·024

75. Corrected mean values of K_v for Spherical Projectiles.

($w = 534{\cdot}22$ grains).

v f.s.	Experimental values of K_v	Correction	Corrected values of K_v	v f.s.	Experimental values of K_v	Correction	Corrected values of K_v
720	119·2			1520	133·6	+0·3	133·9
740	113·2			1540	132·4	+0·1	132·5
760	106·5			1560	131·4	−0·3	131·1
780	106·8			1580	129·8	−0·1	129·7
800	118·2			1600	128·1	+0·2	128·3
820	128·2			1620	126·7	+0·2	126·9
840	133·9	+6·9	140·8	1640	125·4	+0·1	125·5
860	136·4	+4·4	140·8	1660	124·0	+0·1	124·1
880	140·0	+0·8	140·8	1680	122·4	+0·3	122·7
900	141·7	−0·9	140·8	1700	121·1	+0·2	121·3
920	141·1	−0·3	140·8	1720	119·8	+0·1	119·9
940	141·0	−0·2	140·8	1740	118·5	0	118·5
960	140·7	+0·1	140·8	1760	117·0	+0·1	117·1
980	141·7	−0·5	141·2	1780	115·2	+0·5	115·7
1000	142·9	−0·9	142·0	1800	114·6	−0·2	114·4
1020	144·0	0	144·0	1820	113·2	−0·1	113·1
1040	147·5	0	147·5	1840	111·7	+0·2	111·9
1060	150·5	0	150·5	1860	111·4	−0·6	110·8
1080	152·9	−0·3	152·6	1880	110·5	−0·7	109·8
1100	154·0	+0·1	154·1	1900	108·9	0	108·9
1120	155·4	−0·3	155·1	1920	107·8	+0·3	108·1
1140	155·3	+0·4	155·7	1940	106·8	+0·5	107·3
1160	156·4	−0·4	156·0	1960	105·2	+1·3	106·5
1180	156·2	−0·2	156·0	1980	105·8	−0·1	105·7
1200	154·9	+0·6	155·5	2000	105·0	−0·1	104·9
1220	154·2	+0·4	154·6	2020	104·2	−0·1	104·1
1240	152·7	+0·7	153·4	2040	103·3	−0·1	103·2
1260	151·4	+0·6	152·0	2060	102·9	−0·7	102·2
1280	150·1	+0·4	150·5	2080	102·0	−0·9	101·1
1300	148·6	+0·1	148·7	2100	100·0	−0·1	99·9
1320	147·6	−0·4	147·2	2120	98·8	−0·1	98·7
1340	146·8	−0·8	146·0	2140	97·9	−0·3	97·6
1360	145·2	−0·5	144·7	2160	96·4	+0·1	96·5
1380	143·5	−0·1	143·4	2180	95·5	−0·1	95·4
1400	142·3	−0·2	142·1	2200	93·9	+0·5	94·4
1420	140·7	+0·1	140·8	2220	93·0	+0·4	93·4
1440	139·2	+0·3	139·5	2240	92·0	+0·4	92·4
1460	137·8	+0·3	138·1	2260	91·3	+0·1	91·4
1480	136·4	+0·3	136·7	2280	91·4	−1·0	90·4
1500	134·8	+0·5	135·3				

76. Reports dated July 23, 1868, July 8, 1879, and Aug. 31, 1880.

Round	K_v
430 f. s.	
455	222·2*
457	126·1
459	135·1
Mean	130·6
435 f. s.	
Mean	133·6
440 f. s.	
455	199·7*
457	126·1
459	141·1
Mean	133·6
465 f. s.	
Mean	129·9
470 f. s.	
454	171·2*
456	108·1
458	153·1
Mean	130·6
475 f. s.	
Mean	120·1
530 f. s.	
442	117·3
453	123·1
Mean	120·2
535 f. s.	
Mean	118·8
540 f. s.	
439	107·7
442	116·0
452	114·2
453	112·6
Mean	112·6
545 f. s.	
Mean	107·2
550 f. s.	
439	100·4
441	89·0
442	116·6
452	105·2
Mean	102·8
555 f. s.	
Mean	101·5
560 f. s.	
438	87·4
439	94·3
440	104·8
441	89·4
442	114·8
Mean	98·1
565 f. s.	
Mean	99·5
570 f. s.	
438	105·9
439	94·3
440	102·1
441	91·0
442	116·0
448	93·7
Mean	100·5
575 f. s.	
Mean	98·6
580 f. s.	
438	123·2
439	93·0
440	99·0
441	93·3
448	90·0
450	160·3*
Mean	99·7
585 f. s.	
Mean	102·6
590 f. s.	
438	139·5
440	88·6
441	94·3
448	85·7
449	177·3*
450	169·8*
451	96·2
Mean	100·9
595 f. s.	
Mean	112·9
600 f. s.	
438	153·9*
448	81·0
449	153·3*
450	105·2
451	115·7
Mean	100·6
605 f. s.	
Mean	113·2
650 f. s.	
436	92·6
437	98·4
Mean	95·5
655 f. s.	
Mean	96·5
660 f. s.	
433	94·2
436	98·4
437	100·4
Mean	97·7
665 f. s.	
Mean	99·6
670 f. s.	
433	94·2
435	101·9
436	103·0
437	100·4
Mean	99·9
675 f. s.	
Mean	100·1
680 f. s.	
426	120·5
433	96·0
434	87·4
435	101·9
436	98·8
437	101·7
447	83·8
Mean	98·6
685 f. s.	
Mean	97·5
690 f. s.	
426	108·8
433	96·8
434	88·7
435	103·2
436	93·9
437	101·7
447	81·4
Mean	96·4
695 f. s.	
Mean	90·7
700 f. s.	
426	94·3
432	72·7
433	96·0
434	89·3
435	103·2
445	72·5
447	79·2
Mean	86·7
705 f. s.	
Mean	84·9
710 f. s.	
426	80·9
432	61·3
434	92·3
435	103·2
443	80·5
445	71·9
447	77·7
Mean	81·1
715 f. s.	
Mean	80·2
720 f. s.	
424	75·0
426	77·6
434	94·9
435	103·6
443	78·9
445	71·9
447	76·4
Mean	82·6
725 f. s.	
Mean	81·0
730 f. s.	
424	74·1
426	77·3
434	96·5
435	105·8
443	78·3
444	70·9
445	69·4
447	76·4
Mean	81·1
735 f. s.	
Mean	77·2
740 f. s.	
424	72·3
425	100·4
428	70·8
443	78·3
444	71·9
446	70·3
Mean	77·3

Round	K_v
745 f. s.	
Mean	78·0
750 f. s.	
55	89·7
57	90·0
138	95·3
424	82·6
425	94·2
428	70·8
443	83·3
444	70·9
446	70·3
Mean	83·0
755 f. s.	
Mean	83·2
760 f. s.	
55	89·7
56	86·4
57	85·4
60	95·2
138	95·3
424	82·9
425	87·2
428	70·8
443	85·8
444	70·9
446	69·0
Mean	83·5
765 f. s.	
Mean	85·5
770 f. s.	
55	90·1
56	84·5
57	82·0
59	102·0
60	91·7
137	95·5
138	95·3
425	80·1

Round	K_v
770 f. s. continued.	
428	69·4
444	71·2
446	68·7
Mean	84·6
775 f. s.	
Mean	81·9
780 f. s.	
57	78·5
59	98·9
60	87·2
135	91·7
137	92·1
425	72·1
427	68·7
428	66·1
446	67·8
Mean	80·3
785 f. s.	
Mean	75·6
790 f. s.	
137	88·2
425	62·2
427	64·5
428	63·9
Mean	69·7
795 f. s.	
Mean	74·6
800 f. s.	
427	61·4
430	62·7
Mean	62·1

Round	K_v
805 f. s.	
Mean	61·9
810 f. s.	
427	62·7
430	59·5
Mean	61·1
815 f. s.	
Mean	57·9
820 f. s.	
429	75·7
430	58·2
Mean	67·0
825 f. s.	
Mean	74·3
830 f. s.	
122	90·1
429	75·4
430	58·5
Mean	74·7
835 f. s.	
Mean	74·9
840 f. s.	
28	64·1
122	90·1
429	76·0
430	58·5
Mean	72·2
845 f. s.	
Mean	74·5

Round	K_v
850 f. s.	
28	62·7
31	62·1
32	62·3
121	92·9
122	90·4
177	61·1
423	64·7
429	74·1
430	59·5
Mean	70·0
855 f. s.	
Mean	69·6
860 f. s.	
27	46·8
28	61·7
29	64·0
30	64·5
31	61·4
32	60·3
121	93·6
122	91·1
177	58·8
421	97·6
422	45·5
423	58·2
429	67·6
Mean	67·0
865 f. s.	
Mean	66·1
870 f. s.	
26	62·6
27	43·6
28	61·0
29	62·2
30	60·4
31	60·8
32	57·8
121	94·2
177	57·3
421	84·1
422	66·3

Round	K_v
870 f. s. continued.	
423	46·3
429	63·9
Mean	63·1
875 f. s.	
Mean	62·4
880 f. s.	
26	61·9
28	60·3
177	57·3
415	85·8
421	70·3
422	80·2
423	40·5
429	62·7
Mean	64·9
885 f. s.	
Mean	75·3
890 f. s.	
26	61·7
178	63·8
415	84·7
418	85·3
421	54·8
422	87·3
Mean	72·9
895 f. s.	
Mean	74·1
900 f. s.	
178	62·6
415	84·5
418	90·9
419	80·6
422	90·8
Mean	81·9

Round	K_v
905 f. s.	
Mean	79·8
910 f. s.	
178	61·4
415	82·1
417	91·5
418	94·0
419	80·6
Mean	81·9
915 f. s.	
Mean	80·2
920 f. s.	
178	60·4
415	76·1
416	80·4
417	84·5
418	93·5
419	75·6
Mean	78·4
925 f. s.	
Mean	75·6
930 f. s.	
24	73·2
415	74·1
416	74·0
417	78·8
418	89·4
419	65·8
Mean	75·9
935 f. s.	
Mean	71·1

Round	K_v
940 f. s.	
20	57·1
24	72·5
25	68·3
415	77·4
416	68·2
417	72·8
418	83·0
419	60·2
Mean	69·9
945 f. s.	
Mean	75·9
950 f. s.	
20	56·5
24	71·9
25	67·6
51	82·8
223	98·1
224	108·5
225	107·3
227	91·5
412	46·6
415	81·2
416	64·3
417	70·4
419	58·0
Mean	77·3
955 f. s.	
Mean	75·9
960 f. s.	
20	55·8
21	57·9
24	71·4
25	67·1
51	82·1
222	68·2
223	92·3
224	102·2
225	107·3
227	81·9
412	58·0

Round	K_v
960 f. s. continued.	
414	65·4
416	63·1
417	66·3
419	57·2
Mean	73·1
965 f. s.	
Mean	75·5
970 f. s.	
20	54·9
21	57·7
24	71·2
25	66·7
50	92·6
51	81·4
53	90·3
103	66·1
222	63·2
223	89·2
224	95·7
226	90·7
412	72·1
414	63·5
416	52·4
417	65·0
Mean	73·3
975 f. s.	
Mean	73·9
980 f. s.	
20	54·2
21	57·4
23	79·3
24	71·1
25	66·5
50	90·3
51	80·7
53	89·8
103	69·0
104	63·0
105	77·4

Round	K_v
980 f. s. continued.	
162	92·6
412	83·4
413	62·6
414	63·5
417	65·0
Mean	72·9
985 f. s.	
Mean	72·9
990 f. s.	
20	53·7
21	57·1
23	78·7
24	71·1
25	66·1
49	68·3
50	85·8
51	80·0
52	72·7
53	88·6
54	81·5
103	71·7
105	81·7
160	75·2
161	70·9
162	91·3
412	89·3
413	64·6
414	68·7
Mean	74·6
995 f. s.	
Mean	74·8
1000 f. s.	
20	53·2
21	56·9
23	78·1
24	71·1
25	65·8
49	68·3

Round	K_v
1000 f. s. continued.	
50	81·3
51	79·3
52	73·8
53	86·6
54	78·2
105	86·2
160	75·2
161	71·7
162	90·0
163	63·0
412	95·8
413	64·8
414	75·5
Mean	74·5
1005 f. s.	
Mean	73·8
1010 f. s.	
20	52·9
21	56·9
23	77·6
24	71·1
25	65·6
49	68·3
50	75·0
51	78·6
52	75·7
53	84·0
54	75·7
159	72·9
160	75·2
161	70·9
162	88·7
163	62·1
175	83·8
412	102·6
413	66·1
414	80·7
Mean	74·2
1015 f. s.	
Mean	73·9

Round	K_v
1020 f. s.	
23	77·0
24	71·0
25	65·1
49	67·9
50	68·2
51	78·1
52	77·8
54	74·0
159	73·5
160	75·2
161	71·3
163	62·1
175	84·4
413	68·6
414	86·2
Mean	73·4
1025 f. s.	
Mean	75·6
1030 f. s.	
23	76·5
49	67·1
51	77·7
52	80·6
54	73·2
159	74·4
163	62·1
175	85·7
413	74·5
414	89·4
Mean	76·1
1035 f. s.	
Mean	81·0
1040 f. s.	
16	97·9
23	75·7
51	77·3
159	74·4
175	87·2
413	80·4
414	93·3
Mean	83·7

Round	K_v
1045 f. s.	
Mean	89·6
1050 f. s.	
14	94·3
16	97·9
174	95·4
175	88·8
176	85·1
413	84·0
Mean	90·9
1055 f. s.	
Mean	91·6
1060 f. s.	
14	93·8
16	97·5
174	95·4
175	91·1
176	85·4
413	89·7
Mean	92·2
1070 f. s.	
Mean	104·5
1080 f. s.	
13	124·1
14	92·2
15	126·9
16	95·6
17	110·0
18	96·9
169	102·8
170	106·1
173	99·7
174	95·7
175	96·2
176	86·0
232	115·7
235	84·4
236	124·2
237	111·5
238	120.0
Mean	105·2

1090 *f. s.*

Mean 106·6

1100 *f. s.*

Round	K_v
1	135·2
3	122·3
13	122·6
14	89·6
15	122·1
16	93·3
17	108·5
18	96·3
38	112·2
169	98·8
170	107·6
171	97·9
172	104·1
173	99·7
174	96·2
176	86·6
232	118·7
233	151·0
234	94·4
235	74·5
236	113·0
237	113·1
238	111·3

Mean 107·3

1110 *f. s.*

Mean 107·4

1120 *f. s.*

Round	K_v
1	134·1
2	93·3
3	124·5
13	120·7
15	115·0
16	91·4
17	107·1
18	95·2
35	104·1
38	111·7
64	101·3
66	106·7
67	103·7
93	124·9
169	91·2
170	107·6
171	96·0

1120 *f. s.* *continued.*

Round	K_v
172	103·2
173	98·9
174	97·1
176	86·6
236	111·5

Mean 105·7

1130 *f. s.*

Mean 107·2

1140 *f. s.*

Round	K_v
1	133·5
2	94·7
3	125·7
4	115·2
16	89·7
17	105·7
18	94·4
35	104·3
38	111·1
61	130·2
64	101·3
66	104·2
67	102·2
88	116·0
91	89·5
93	131·6
139	100·9
141	118·0
143	113·1
171	95·4
172	103·2
173	97·3
174	97·6

Mean 107·6

1150 *f. s.*

Mean 109·3

1160 *f. s.*

Round	K_v
1	132·8
2	97·5
3	126·1
4	110·4
17	104·2
19	114·1

1160 *f. s.* *continued.*

Round	K_v
35	104·5
36	114·9
38	110·7
61	129·6
64	101·3
66	102·3
67	101·2
87	112·8
88	119·4
91	94·5
93	135·9
124	112·6
139	100·9
140	110·4
141	115·8
142	101·7
143	113·1
174	98·5
208	103·4
209	97·7
211	116·6
212	94·1

Mean 109·9

1170 *f. s.*

Mean 110·0

1180 *f. s.*

Round	K_v
1	132·1
2	100·9
3	125·3
4	105·7
5	101·3
19	114·1
35	104·7
36	114·7
38	110·3
61	129·0
64	101·6
66	100·8
67	100·8
87	111·1
88	119·7
91	101·4
93	139·9
124	112·6
139	100·2
140	109·3
141	115·3

1180 *f. s.* *continued.*

Round	K_v
142	100·9
143	113·7
208	106·2
209	99·1
210	96·3
211	125·6
212	87·8

Mean 110·0

1190 *f. s.*

Mean 109·9

1200 *f. s.*

Round	K_v
2	104·2
3	123·2
4	101·4
5	96·1
35	104·8
36	114·2
37	114·0
38	110·0
61	128·5
64	102·3
66	99·7
67	100·5
86	94·2
87	111·1
88	115·9
89	106·7
92	88·5
94	110·9
112	114·4
124	112·6
126	113·7
139	99·1
140	107·0
141	113·0
142	100·9
143	115·1
148	107·8
149	112·8
150	103·4
209	100·6
210	96·2
240	99·3

Mean 106·9

1210 *f. s.*

Mean 107·0

1220 *f. s.*

Round	K_v
6	144·5
7	116·0
10	121·0
12	123·5
33	130·5
35	105·0
36	113·6
37	113·8
38	109·5
43	106·0
61	127·9
64	103·0
66	98·7
67	100·5
87	111·1
94	109·9
112	113·4
124	112·3
126	112·5
131	107·9
132	104·4
133	111·5
134	117·8
140	102·5
141	111·0
142	98·4
143	116·4
148	107·0
149	113·2
150	102·6
152	107·6
153	102·4
229	84·7
239	100·2
240	93·3

Mean 110·1

1230 *f. s.*

Mean 110·1

1240 *f. s.*

Round	K_v
6	141·0
7	114·7
9	116·6
10	119·9
12	122·5
33	130·0

1240 *f. s.* *continued.*

Round	K_v
35	105·2
36	112·8
37	113·6
38	108·9
43	105·7
61	127·3
62	121·0
63	106·6
64	103·7
66	98·2
67	101·1
94	108·4
111	120·4
112	112·3
124	112·0
126	111·7
130	105·4
131	107·2
132	104·1
133	111·5
134	117·5
148	106·3
149	113·3
150	102·1
152	107·6
153	102·4
166	95·2
168	97·1
218	111·9
220	108·5
221	120·9
228	118 2
229	84·7
239	92·0
240	91·7

Mean 110·0

1250 *f. s.*

Mean 110·2

1260 *f. s.*

Round	K_v
6	138·2
7	112·9
9	115·5
10	118·9
11	121·8
12	121·1
33	129·6
34	94·0
35	105·4

1260 *f. s. continued.*

Round	K_v
36	111·9
37	113·5
38	108·6
40	106·0
43	105·5
62	121·0
63	105·4
64	104·4
66	97·9
67	101·9
94	106·3
96	121·6
111	119·4
112	111·3
124	111·6
126	111·1
130	105·1
131	106·7
132	103·9
133	111·5
134	117·2
148	105·8
149	113·3
150	101·8
151	107·5
152	107·6
153	102·2
164	110·2
165	100·2
166	93·7
167	101·5
168	96·3
218	111·0
219	117·0
220	119·0
221	119·7
228	124·0
229	84·7
239	84·8
Mean	109·6

1270 *f. s.*

Mean 111·0

1280 *f. s.*

Round	K_v
6	136·1
7	110·3
9	114·4

1280 *f. s. continued.*

Round	K_v
10	117·8
11	120·8
12	118·7
33	129·1
34	92·6
35	105·5
36	111·2
37	113·5
38	108·2
40	105·3
43	105·3
44	109·4
62	121·0
66	97·5
94	104·1
96	120·6
97	113·1
98	122·1
101	121·8
110	125·9
111	118·5
112	110·2
124	111·2
126	110·8
127	109·4
130	104·8
131	106·2
132	103·7
133	111·5
134	116·9
148	105·4
149	113·3
150	101·5
151	106·4
152	107·5
153	101·9
164	110·2
165	98·8
166	92·1
167	100·7
168	95·7
218	110·5
219	104·5
220	126·3
221	119·0
Mean	110·9

1290 *f. s.*

Mean 110·1

1300 *f. s.*

Round	K_v
6	134·4
7	107·3
9	113·4
10	116·9
11	119·8
12	116·4
33	128·9
34	91·3
35	105·7
36	110·4
37	113·5
38	107·8
40	104·7
41	105·1
43	105·0
44	108·7
94	101·9
96	119·7
97	110·0
98	118·3
99	109·1
100	118·7
101	118·0
110	124·6
111	117·5
112	108·4
124	110·5
126	110·8
127	108·8
130	104·5
131	105·6
132	103·7
133	111·5
134	116·6
148	105·1
149	113·3
150	101·1
151	105·5
152	107·3
153	101·9
164	110·1
165	96·0
166	91·9
167	99·3
168	95·2
221	119·0
Mean	109·9

1310 *f. s.*

Mean 108·7

1320 *f. s.*

Round	K_v
7	103·9
10	116·3
11	118·8
12	114·0
33	128·6
35	105·7
36	109·6
37	113·5
38	107·3
40	104·2
41	104·7
43	104·7
44	108·1
94	99·8
96	118·8
97	107·9
98	114·5
99	105·0
100	114·9
110	123·3
111	116·6
112	105·7
124	109·9
126	111·0
127	108·5
130	104·2
131	105·0
132	103·7
133	111·4
134	116·5
148	104·7
149	113·2
150	100·7
151	104·5
152	106·9
153	101·9
164	108·9
165	93·1
167	98·9
Mean	108·9

1330 *f. s.*

Mean 108·5

1340 *f. s.*

Round	K_v
7	100·2
12	111·3
35	105·7
37	113·5

1340 *f. s. continued.*

Round	K_v
40	103·8
41	104·3
43	104·5
44	107·5
96	117·9
98	110·8
99	102·5
100	110·1
126	111·4
127	108·3
130	103·9
131	104·6
132	103·7
133	111·2
134	116·4
148	104·5
149	112·9
150	100·5
151	103·6
152	106·6
153	101·9
164	107·7
Mean	107·3

1350 *f. s.*

Mean 106·5

1360 *f. s.*

Round	K_v
7	96·6
40	103·4
41	103·8
43	104·3
44	106·8
99	101·6
100	106·4
126	112·0
127	108·2
130	103·8
131	104·2
132	103·7
133	111·1
134	116·3
148	104·5
149	112·4
152	106·3
153	101·9
Mean	106·0

1370 *f. s.*

Mean 106·5

1380 *f. s.*

Round	K_v
40	103·3
41	103·6
43	104·3
44	106·1
127	108·2
130	103·6
131	103·8
132	103·5
133	111·0
134	116·1
153	101·9
Mean	105·9

1390 *f. s.*

Mean 105·6

1400 *f. s.*

Round	K_v
40	103·1
41	103·3
43	104·3
44	105·5
127	108·3
130	103·5
131	103·4
132	103·2
133	110·9
134	116·1
154	99·8
155	110·2
156	107·5
157	108·6
158	98·9
Mean	105·8

1410 *f. s.*

Mean 105·6

1420 *f. s.*

Round	K_v
39	108·2
40	103·0
41	102·8
43	104·2
44	104·9
116	89·6
127	108·6
130	103·4
131	103·1
132	102·7
133	110·9
134	116·1
154	98·6
155	107·3
156	105·1
157	105·9
158	98·3
Mean	104·3

1430 *f. s.* Mean 103·4

1440 *f. s.*

Round	K_v
39	108·0
40	103·2
41	102·4
43	104·1
44	104·4
114	105·6
116	90·1
127	108·9
130	103·4
131	102·9
132	102·2
133	110·9
154	97·6
155	104·6
156	102·7
157	103·1
158	97·7
Mean	103·0

1450 *f. s.* Mean 102·5

1460 *f. s.*

Round	K_v
39	107·9
40	103·3
41	101·9
43	104·0
44	103·7
113	98·2
114	104·8
116	90·5
127	109·4
129	98·9
130	103·4
132	101·6
133	110·9
154	96·6
155	102·0
156	100·2
157	100·3
158	97·2
Mean	101·9

1470 *f. s.* Mean 101·1

1480 *f. s.*

Round	K_v
39	107·7
40	103·5
41	101·4
43	104·0
44	103·1
113	97·8
114	104·0
116	91·0
127	109·8
129	98·9
130	103·4
132	100·9
133	110·9
147	90·9
154	96·1
155	99·3
156	98·1
157	97·3
158	96·7
Mean	100·8

1490 *f. s.* Mean 99·6

1500 *f. s.*

Round	K_v
39	107·6
40	103·8
41	101·0
43	104·0
44	102·6
113	97·3
114	102·8
116	91·5
130	103·4
132	100·1
145	93·2
147	90·9
154	95·9
155	96·7
156	95·9
157	94·4
158	96·2
Mean	98·7

1510 *f. s.* Mean 97·3

1520 *f. s.*

Round	K_v
39	107·5
40	104·0
41	100·6
44	102·2
113	96·9
114	101·7
116	91·9
117	96·4
145	92·7
146	88·7
147	90·9
154	95·6
155	94·0
156	93·8
157	91·4
158	95·6
Mean	96·5

1530 *f. s.* Mean 96·1

1540 *f. s.*

Round	K_v
39	107·4
40	104·4
41	100·2
44	101·7
113	96·3
114	100·5
115	104·0
116	92·3
117	95·2
145	92·2
146	88·7
147	90·7
154	95·3
155	91·4
156	91·7
157	88·4
158	95·1
Mean	96·2

1550 *f. s.* Mean 95·5

1560 *f. s.*

Round	K_v
40	104·7
44	101·1
113	95·5
114	99·3
115	102·9
116	92·7
117	94·0
145	91·7
146	88·7
147	90·4
154	95·1
155	88·7
156	89·6
157	85·2
158	94·6
Mean	94·3

1570 *f. s.* Mean 93·0

1580 *f. s.*

Round	K_v
44	100·5
113	94·3
114	98·2
115	101·8
116	92·8
117	93·1
145	91·3
146	88·7
147	90·4
154	94·9
155	86·1
156	87·5
157	81·8
158	94·1
Mean	92·5

1590 *f. s.* Mean 91·4

1600 *f. s.*

Round	K_v
113	93·2
115	100·7
117	92·4
145	91·0
146	88·6
147	90·3
154	94·6
155	83·4
156	85·4
157	78·4
158	93·6
472	87·3
Mean	89·9

1610 *f. s.* Mean 88·9

1620 *f. s.*

Round	K_v
115	99·6
145	90·7
146	88·3
147	90·1
154	94·4
155	80·7
156	83·3
158	93·2

1620 *f. s.* *continued.*

Round	K_v
470	72·0
472	87·3
Mean	88·0

1630 *f. s.* Mean 83·9

1640 *f. s.*

Round	K_v
144	73·5
145	90·2
146	88·1
147	90·0
470	75·5
472	87·3
Mean	84·1

1650 *f. s.* Mean 84·4

1660 *f. s.*

Round	K_v
144	73·5
145	89·9
146	87·8
147	90·0
470	78·9
472	87·3
Mean	84·6

1670 *f. s.* Mean 84·8

1680 *f. s.*

Round	K_v
144	73·5
145	89·7
146	87·6
147	89·9
470	81·1
472	86·7
Mean	84·8

Round	K_v
1690 f. s.	
Mean	84·8
1700 f. s.	
144	73·5
145	89·4
146	87·4
147	89·7
470	83·6
472	84·6
Mean	84·7
1710 f. s.	
Mean	83·7
1720 f. s.	
145	89·2
146	87·2
470	85·4
471	71·8
472	82·7
Mean	83·3
1730 f. s.	
Mean	82·4
1740 f. s.	
462	87·6
470	87·7
471	68·5
472	81·0
Mean	81·2
1750 f. s.	
Mean	80·2
1760 f. s.	
462	89·5
463	81·1
470	90·0
471	65·7
Mean	81·6
1770 f. s.	
Mean	80·7
1780 f. s.	
462	91·3*
463	80·3
Mean	80·3
1790 f. s.	
Mean	79·9
1800 f. s.	
462	92·0*
463	79·4
Mean	79·4
1810 f. s.	
Mean	75·2
1820 f. s.	
461	71·3
462	92·0*
463	78·6
Mean	75·0
1830 f. s.	
Mean	75·1
1840 f. s.	
461	72·0
462	92·0*
463	78·6
Mean	75·3
1850 f. s.	
Mean	76·8
1860 f. s.	
461	73·5
462	91·1
463	78·6
502	64·4
Mean	76·9
1870 f. s.	
Mean	77·0
1880 f. s.	
461	75·6
462	89·8
463	78·6
473	65·8
502	64·7
Mean	74·9
1890 f. s.	
Mean	73·8
1900 f. s.	
461	78·3
462	88·4
463	77·6
473	68·2
474	71·8
475	67·8
476	67·7
502	65·1
Mean	73·1
1910 f. s.	
Mean	72·5
1920 f. s.	
461	81·6
462	87·0
463	76·5
473	68·7
474	71·4
475	69·1
476	67·7
1920 f. s. continued.	
477	67·7
502	65·1
Mean	72·8
1930 f. s.	
Mean	71·4
1940 f. s.	
473	69·5
474	71·0
475	70·8
476	68·1
477	68·4
502	65·1
Mean	68·8
1950 f. s.	
Mean	69·4
1960 f. s.	
473	70·2
474	70·7
475	72·1
476	68·3
477	68·8
479	66·8
497	74·5
502	65·0
Mean	69·6
1970 f. s.	
Mean	68·7
1980 f. s.	
473	70·6
474	70·7
475	73·3
476	68·3
477	69·5
479	66·8
481	61·2
1980 f. s. continued.	
482	62·2
497	74·5
501	59·7
502	64·3
Mean	67·4
1990 f. s.	
Mean	67·9
2000 f. s.	
473	71·4
474	70·7
475	74·3
476	67·9
477	70·1
479	66·8
480	66·1
481	61·7
482	62·6
497	74·7
500	73·0
501	59·7
502	63·5
Mean	67·9
2010 f. s.	
Mean	67·9
2020 f. s.	
473	72·5
474	70·7
475	74·7
476	67·7
477	70·1
479	66·8
480	65·7
481	62·2
482	63·0
497	74·9
500	72·7
501	59·7
502	62·9
Mean	68·0
2030 f. s.	
Mean	67·8
2040 f. s.	
473	73·6
474	70·7
475	74·4
476	67·7
477	70·1
478	65·2
479	66·7
480	65·9
481	62·6
482	63·7
491	67·4
493	68·1
497	75·0
498	71·8
499	66·4
500	72·1
501	59·7
502	62·6
Mean	68·0
2050 f. s.	
Mean	68·0
2060 f. s.	
473	74·5
474	70·1
475	73·5
476	67·7
477	70·1
478	65·6
479	66·3
480	66·1
481	63·0
482	64·6
491	67·1
493	68·4
497	75·0
498	71·6
499	66·4
500	71·6
501	59·4
502	62·2
Mean	68·0
2070 f. s.	
Mean	67·9

2080 *f. s.*

Round	K_v
473	75·1
474	69·6
475	72·5
476	67·6
477	69·7
478	66·0
479	66·2
480	65·7
481	63·4
482	65·8
490	62·2
491	67·0
492	57·0
493	68·6
497	74·8
498	71·3
499	66·4
500	71·6
501	59·0
502	61·9
Mean	67·1

2090 *f. s.*

Mean 67·1

2100 *f. s.*

Round	K_v
473	75·9
474	69·5
475	71·1
476	67·2
477	69·4
478	66·2
479	66·2
480	65·8
481	63·8
482	66·7
490	61·8
491	67·0
492	57·3
493	68·9
494	67·0
495	58·9
497	74·6
498	71·3
499	66·4
500	71·5
501	58·7
502	61·6
Mean	66·7

2110 *f. s.*

Mean 66·6

2120 *f. s.*

Round	K_v
473	76·9
474	69·5
475	69·8
476	66·9
477	69·0
478	66·2
479	66·2
480	66·2
481	64·2
482	67·4
490	61·5
491	67·0
492	57·6
493	69·2
494	66·4
495	58·6
497	74·5
498	71·3
499	66·6
500	71·2
501	58·3
Mean	66·9

2130 *f. s.*

Mean 66·3

2140 *f. s.*

Round	K_v
474	69·5
475	68·8
476	66·5
477	68·7
478	66·4
479	66·2
480	65·8
481	64·5
482	68·2
490	61·2
491	67·0
492	58·0
493	69·5
494	65·9
495	58·2
497	74·5

2140 *f. s.* *continued.*

Round	K_v
498	71·3
499	66·9
500	71·0
501	58·0
Mean	66·3

2150 *f. s.*

Mean 66·3

2160 *f. s.*

Round	K_v
477	68·3
478	66·8
479	66·2
480	65·6
481	64·9
482	68·9
490	60·9
491	67·3
492	58·3
493	69·8
494	65·3
495	57·9
497	74·3
498	71·3
499	67·2
500	70·7
501	58·0
Mean	66·0

2170 *f. s.*

Mean 65·9

2180 *f. s.*

Round	K_v
478	66·4
479	66·5
480	65·6
481	65·3
482	69·6
490	60·6
491	67·5
492	58·6
493	70·0
494	64·8
495	57·4
497	74·0

2180 *f. s.* *continued.*

Round	K_v
498	71·3
499	67·4
500	70·5
501	58·0
Mean	65·8

2190 *f. s.*

Mean 65·9

2200 *f. s.*

Round	K_v
478	66·1
479	66·8
480	65·6
481	65·6
482	69·9
490	60·9
491	68·1
492	58·8
493	70·3
494	64·2
495	56·7
497	73·8
498	71·2
499	67·5
500	70·8
501	58·0
Mean	65·9

2210 *f. s.*

Mean 65·9

2220 *f. s.*

Round	K_v
478	65·7
479	66·4
480	65·6
481	66·0
482	69·9
490	61·0
491	68·6
492	59·4
493	70·5
494	63·6
495	55·7
497	73·6
498	71·1

2220 *f. s.* *continued.*

Round	K_v
499	67·5
500	71·1
501	58·0
Mean	65·9

2230 *f. s.*

Mean 65·8

2240 *f. s.*

Round	K_v
480	65·3
482	69·7
490	60·8
491	69·3
492	60·1
493	70·7
494	63·1
495	55·1
497	73·3
498	70·8
499	67·7
500	71·6
501	58·0
Mean	65·8

2250 *f. s.*

Mean 65·8

2260 *f. s.*

Round	K_v
482	69·3
490	60·7
491	70·1
492	60·6
493	70·7
494	62·6
495	54·8
497	73·1
498	70·4
499	68·0
500	72·1
501	58·0
Mean	65·9

2270 *f. s.*

Mean 65·5

2280 *f. s.*

Round	K_v
490	60·9
491	70·8
492	61·1
493	70·7
494	62·1
495	53·8
497	72·9
498	69·9
499	68·0
500	72·3
Mean	66·3

2290 *f. s.*

Mean 65·5

2300 *f. s.*

Round	K_v
490	61·1
491	71·5
492	61·4
493	70·7
494	61·8
495	52·6
498	69·5
499	67·7
500	72·6
Mean	65·4

2310 *f. s.*

Mean 65·4

2320 *f. s.*

Round	K_v
490	61·1
491	71·9
492	61·6
493	70·7
494	61·5
495	51·6
498	69·0
499	67·5
Mean	64·4

Round	K_v
2330 f. s.	
Mean	62·8
2340 f. s.	
485	51·1
491	72·1
492	61·6
493	70·6
494	61·3
495	50·6
498	68·5
499	67·5
Mean	62·9
2350 f. s.	
Mean	62·8
2360 f. s.	
485	51·4
491	72·3
492	61·6
493	70·4
494	61·1
495	49·4
498	68·3
499	67·5
Mean	62·8
2370 f. s.	
Mean	60·5
2380 f. s.	
485	52·0
486	49·9
488	49·9
491	72·6
492	61·6
493	70·2
494	60·9
498	68·1
Mean	60·7
2390 f. s.	
Mean	58·4
2400 f. s.	
485	52·5
486	49·9
487	54·9
488	49·5
491	72·8
492	61·6
493	70·2
494	60·6
496	53·4
Mean	58·4
2410 f. s.	
Mean	57·8
2420 f. s.	
483	51·5
485	53·1
486	49·9
487	54·3
488	49·3
493	70·2
494	60·3
496	53·1
Mean	55·2
2430 f. s.	
Mean	53·0
2440 f. s.	
483	51·5
485	53·7
486	49·9
487	53·7
488	49·3
494	60·0
496	53·0
Mean	53·0
2450 f. s.	
Mean	51·9
2460 f. s.	
483	51·5
485	54·7
486	49·9
487	53·2
488	49·3
489	47·7
496	53·0
Mean	51·3
2470 f. s.	
Mean	51·4
2480 f. s.	
483	51·5
485	55·7
486	50·0
487	52·9
488	49·3
489	47·7
496	52·7
Mean	51·4
2490 f. s.	
Mean	51·5
2500 f. s.	
483	51·5
485	57·1
486	50·3
487	52·6
488	49·4
489	47·7
496	52·2
Mean	51·5
2510 f. s.	
Mean	51·7
2520 f. s.	
483	51·5
485	58·5
486	50·4
487	52·4
488	49·8
489	48·0
496	51·8
Mean	51·8
2530 f. s.	
Mean	51·9
2540 f. s.	
483	51·5
485	59·9
486	50·4
487	52·2
488	50·1
489	48·1
496	51·5
Mean	52·0
2550 f. s.	
Mean	52·0
2560 f. s.	
483	51·2
485	61·1
486	50·5
487	51·9
488	50·3
489	47·9
496	51·4
Mean	52·0
2570 f. s.	
Mean	52·1
2580 f. s.	
483	50·9
485	62·4
486	50·7
2580 f. s. continued.	
487	51·7
488	50·6
496	51·4
Mean	53·0
2590 f. s.	
Mean	53·1
2600 f. s.	
483	50·7
485	63·5
486	50·9
487	51·5
488	50·8
496	51·5
Mean	53·2
2610 f. s.	
Mean	53·3
2620 f. s.	
483	50·4
485	64·7
486	50·9
487	51·1
488	50·9
496	51·8
Mean	53·3
2630 f. s.	
Mean	51·0
2640 f. s.	
483	50·4
485	65·8*
486	50·9
487	50·9
488	50·9
496	51·9
Mean	51·0
2650 f. s.	
Mean	51·5
2660 f. s.	
483	50·4
484	54·1
485	66·9*
486	50·9
487	50·9
488	50·9
496	51·7
Mean	51·5
2670 f. s.	
Mean	51·4
2680 f. s.	
483	50·3
484	54·1
485	68·0*
486	50·9
487	50·9
488	50·6
496	51·4
Mean	51·4
2690 f. s.	
Mean	51·3
2700 f. s.	
483	50·0
484	54·1
485	68·9*
486	50·9
487	50·9
488	50·4
496	51·4
Mean	51·3
2710 f. s.	
Mean	51·3
2720 f. s.	
483	49·8
484	54·1
485	70·0*
486	50·9
487	50·9
488	50·4
496	51·4
Mean	51·3
2730 f. s.	
Mean	51·2
2740 f. s.	
483	49·6
484	54·2
485	71·0*
486	50·8
487	51·0
488	50·4
496	51·4
Mean	51·2
2750 f. s.	
Mean	51·2
2760 f. s.	
483	49·3
484	54·4
486	50·6
487	51·2
496	51·4
Mean	51·4
2770 f. s.	
Mean	52·0
2780 f. s.	
484	54·6
486	50·4
487	51·5
496	51·4
Mean	52·0

77. Corrected mean values of K_v for Ogival-headed Projectiles.

(w = 534·22 grains.) Cubic Law.

v f.s.	Experimental values of K_v	Corrections	Corrected values of K_v	v f.s.	Experimental values of K_v	Corrections	Corrected values of K_v
430	130·6	+10·1	140·7	775	81·9	−3·8	78·1
435	133·6	+5·5	139·1	780	80·3	−2·7	77·6
440	133·6	+3·9	137·5	785	75·6	+1·5	77·1
465	129·9	+0·2	130·1	790	69·7	+6·9	76·6
470	130·6	−1·9	128·7	795	74·6	+1·5	76·1
475	120·1	+7·3	127·4	800	62·1	+13·5	75·6
530	120·2	−6·0	114·2	805	61·9	+13·2	75·1
535	118·8	−5·7	113·1	810	61·1	+13·5	74·6
540	112·6	−0·6	112·0	815	57·9	+16·3	74·2
545	107·2	+3·8	111·0	820	67·0	+6·9	73·9
550	102·8	+7·2	110·0	825	74·3	−0·6	73·7
555	101·5	+7·5	109·0	830	74·7	−1·1	73·6
560	98·1	+9·9	108·0	835	74·9	−1·3	73·6
565	99·5	+7·6	107·1	840	72·2	+1·4	73·6
570	100·5	+5·6	106·1	845	74·5	−0·9	73·6
575	98·6	+6·6	105·2	850	70·0	+3·6	73·6
580	99·7	+4·6	104·3	855	69·6	+4·0	73·6
585	102·6	+0·8	103·4	860	67·0	+6·6	73·6
590	100·9	+1·6	102·5	865	66·1	+7·5	73·6
595	112·9	−11·2	101·7	870	63·1	+10·5	73·6
600	100·6	+0·2	100·8	875	62·4	+11·2	73·6
605	113·2	−13·2	100·0	880	64·9	+8·7	73·6
650	95·5	−2·4	93·1	885	75·3	−1·7	73·6
655	96·5	−4·1	92·4	890	72·9	+0·7	73·6
660	97·7	−6·0	91·7	895	74·1	−0·5	73·6
665	99·6	−8·6	91·0	900	81·9	−8·3	73·6
670	99·9	−9·6	90·3	905	79·8	−6·2	73·6
675	100·1	−10·5	89·6	910	81·9	−8·3	73·6
680	98·6	−9·6	89·0	915	80·2	−6·6	73·6
685	97·5	−9·2	88·3	920	78·4	−4·8	73·6
690	96·4	−8·7	87·7	925	75·6	−2·0	73·6
695	90·7	−3·7	87·0	930	75·9	−2·3	73·6
700	86·7	−0·3	86·4	935	71·1	+2·5	73·6
705	84·9	+0·9	85·8	940	69·9	+3·7	73·6
710	81·1	+4·1	85·2	945	75·9	−2·3	73·6
715	80·2	+4·4	84·6	950	77·3	−3·7	73·6
720	82·6	+1·4	84·0	955	75·9	−2·3	73·6
725	81·0	+2·4	83·4	960	73·1	+0·5	73·6
730	81·1	+1·8	82·9	965	75·5	−1·9	73·6
735	77·2	+5·1	82·3	970	73·3	+0·3	73·6
740	77·3	+4·5	81·8	975	73·9	−0·3	73·6
745	78·0	+3·2	81·2	980	72·9	+0·7	73·6
750	83·0	−2·3	80·7	985	72·9	+0·7	73·6
755	83·2	−3·1	80·1	990	74·6	−1·0	73·6
760	83·5	−3·9	79·6	995	74·8	−1·2	73·6
765	85·5	−6·4	79·1	1000	74·5	−0·9	73·6
770	84·6	−6·0	78·6	1005	73·8	−0·2	73·6

Corrected mean values of K_v for Ogival-headed Projectiles—(*cont.*).

v f. s.	Experimental values of K_v	Corrections	Corrected values of K_v	v f. s.	Experimental values of K_v	Corrections	Corrected values of K_v
1010	74·2	−0·4	73·8	1410	105·6	−1·0	104·6
1015	73·9	+0·2	74·1	1420	104·3	−0·3	104·0
1020	73·4	+1·2	74·6	1430	103·4	0	103·4
1025	75·6	−0·2	75·4	1440	103·0	−0·2	102·8
1030	76·1	+0·5	76·6	1450	102·5	−0·4	102·1
1035	81·0	−2·6	78·4	1460	101·9	−0·5	101·4
1040	83·7	−2 9	80·8	1470	101·1	−0·4	100·7
1045	89·6	−5·8	83·8	1480	100·8	−0·9	99·9
1050	90·9	−3·6	87·3	1490	99·6	−0·4	99·2
1055	91·6	−0·8	90·8	1500	98·7	−0·3	98·4
1060	92·2	+1·8	94·0	1510	97·3	+0·4	97·7
1065	92·5	+4·1	96·6	1520	96·5	+0·3	96·8
1070	104·5	−5·8	98·7	1530	96·1	0	96·1
1080	105·2	−3·0	102·2	1540	96·2	−0·9	95·3
1090	106·6	−1·7	104·9	1550	95·5	−1·0	94·5
1100	107·3	−0·4	106·9	1560	94·3	−0·6	93·7
1110	107·4	+1·0	108·4	1570	93·0	−0·1	92·9
1120	105·7	+3·5	109·2	1580	92·5	−0·4	92·1
1130	107·2	+2·4	109·6	1590	91·4	−0·1	91·3
1140	107·6	+2·0	109·6	1600	89·9	+0·6	90·5
1150	109·3	+0·3	109·6	1610	88·9	+0·9	89·8
1160	109·9	−0·3	109·6	1620	88·0	+1·1	89·1
1170	110·0	−0·4	109·6	1630	83·9	+4·5	88·4
1180	110·0	−0·4	109·6	1640	84·1	+3·6	87·7
1190	109·9	−0·3	109·6	1650	84·4	+2·6	87·0
1200	106·9	+2·7	109·6	1660	84·6	+1·7	86·3
1210	107·0	+2·6	109·6	1670	84·8	+0·8	85·6
1220	110·1	−0·5	109·6	1680	84·8	+0·1	84·9
1230	110·1	−0·5	109·6	1690	84·8	−0·6	84·2
1240	110·0	−0·4	109·6	1700	84·7	−1·2	83·5
1250	110·2	−0·6	109·6	1710	83·7	−0·9	82·8
1260	109·6	0	109·6	1720	83·3	−1·2	82·1
1270	111·0	−1·4	109·6	1730	82·4	−0·9	81·5
1280	110·9	−1·3	109·6	1740	81·2	−0·3	80·9
1290	110·1	−0·5	109·6	1750	80·2	+0·1	80·3
1300	109·9	−0·5	109·4	1760	81·6	−1·9	79·7
1310	108·7	+0·4	109·1	1770	80·7	−1·5	79·2
1320	108·9	−0·1	108·8	1780	80·3	−1·7	78·6
1330	108·5	0	108·5	1790	79·9	−1·9	78·0
1340	107·3	+0·8	108·1	1800	79·4	−2·0	77·4
1350	106·5	+1·2	107·7	1810	75·2	+1·6	76·8
1360	106·0	+1·2	107·2	1820	75·0	+1·2	76·2
1370	106·5	+0·3	106·8	1830	75·1	+0·6	75·7
1380	105·9	+0·4	106·3	1840	75·3	−0·1	75·2
1390	105·6	+0·2	105·8	1850	76·8	−2·1	74 7
1400	105·8	−0·6	105·2	1860	76·9	−2·6	74·3

Corrected mean values of K_v for Ogival-headed Projectiles—(*cont.*).

v f.s.	Experimental values of K_v	Corrections	Corrected values of K_v	v f.s.	Experimental values of K_v	Corrections	Corrected values of K_v
1870	77·0	−3·2	73·8	2330	62·8	−2·1	60·7
1880	74·9	−1·6	73·3	2340	62·9	−0·7	60·2
1890	73·8	−1·0	72·8	2350	62·8	−3·1	59·7
1900	73·1	−0·9	72·2	2360	62·8	−3·7	59·1
1910	72·5	−0·8	71·7	2370	60·5	−1·9	58·6
1920	72·8	−1·6	71·2	2380	60·7	−2·7	58·0
1930	71·4	−0·6	70·8	2390	58·4	−0·9	57·5
1940	68·8	+1·6	70·4	2400	58·4	−1·4	57·0
1950	69·4	+0·6	70·0	2410	57·8	−1·3	56·5
1960	69·6	0	69·6	2420	55·2	+0·8	56·0
1970	68·7	+0·6	69·3	2430	53·0	+2·6	55·6
1980	67·4	+1·6	69·0	2440	53·0	+2·1	55·1
1990	67·9	+0·9	68·8	2450	51·9	+2·8	54·7
2000	67·9	+0·6	68·5	2460	51·3	+3·0	54·3
2010	67·9	+0·3	68·2	2470	51·4	+2·5	53·9
2020	68·0	0	68·0	2480	51·4	+2·2	53·6
2030	67·8	0	67·8	2490	51·5	+1·7	53·2
2040	68·0	−0·3	67·7	2500	51·5	+1·4	52·9
2050	68·0	−0·5	67·5	2510	51·7	+1·0	52·7
2060	68·0	−0·6	67·4	2520	51·8	+0·7	52·5
2070	67·9	−0·6	67·3	2530	51·9	+0·4	52·3
2080	67·1	+0·1	67·2	2540	52·0	+0·2	52·2
2090	67·1	0	67·1	2550	52·0	0	52·0
2100	66·7	+0·3	67·0	2560	52·0	−0·1	51·9
2110	66·6	+0·3	66·9	2570	52·1	−0·3	51·8
2120	66·9	−0·1	66·8	2580	53·0	−1·3	51·7
2130	66·3	+0·4	66·7	2590	53·1	−1·5	51·6
2140	66·3	+0·3	66·6	2600	53·2	−1·7	51·5
2150	66·3	+0·2	66·5	2610	53·3	−1·9	51·4
2160	66·0	+0·4	66·4	2620	53·3	−1·9	51·4
2170	65·9	+0·4	66·3	2630	51·0	+0·4	51·4
2180	65·8	+0·3	66·1	2640	51·0	+0·4	51·4
2190	65·9	+0·1	66·0	2650	51·5	−0·1	51·4
2200	65·9	−0·1	65·8	2660	51·5	−0·1	51·4
2210	65·9	−0·3	65·6	2670	51·4	0	51·4
2220	65·9	−0·6	65·3	2680	51·4	0	51·4
2230	65·8	−0·7	65·1	2690	51·3	0	51·3
2240	65·8	−0·9	64·9	2700	51·3	0	51·3
2250	65·8	−1·2	64·6	2710	51·3	0	51·3
2260	65·9	−1·7	64·2	2720	51·3	0	51·3
2270	65·5	−1·8	63·7	2730	51·2	0	51·2
2280	66·3	−3·1	63·2	2740	51·2	0	51·2
2290	65·5	−2·8	62·7	2750	51·2	0	51·2
2300	65·4	−3·2	62·2	2760	51·4	−0·2	51·2
2310	65·4	−3·7	61·7	2770	52·0	−0·8	51·2
2320	64·4	−3·2	61·2	2780	52·0	−0·8	51·2

78. Report dated July 8, 1879.

Round	K_v	Round	K_v	Round	K_v	Round	K_v	Round	K_v	Round	K_v
1640 *f. s.*		1680 *f. s.*		1720 *f. s.*		1760 *f. s.*		1800 *f. s.*		1840 *f. s.*	
467	106·4	467	106·4	467	106·4	464	106·4	467	106·4	467	105·9
468	127·2	468	123·6	468	119·4	468	112·0	468	100·8	468	89·0
469	113·1	469	114·2	469	113·9	469	113·9	469	113·4	469	113·1
Mean	115·6	Mean	114·7	Mean	113·2	Mean	110·8	Mean	106·9	Mean	102·7
1650 *f. s.*		1690 *f. s.*		1730 *f. s.*		1770 *f. s.*		1810 *f. s.*		1850 *f. s.*	
Mean	115·3	Mean	114·3	Mean	112·7	Mean	109·9	Mean	106·0	Mean	101·6
1660 *f. s.*		1700 *f. s.*		1740 *f. s.*		1780 *f. s.*		1820 *f. s.*		1860 *f. s.*	
467	106·4	467	106·4	467	106·4	467	106·4	467	106·4	467	105·6
468	125·4	468	121·7	468	116·0	468	107·0	468	94·8	468	83·4
469	113·1	469	113·9	469	113·9	469	113·9	469	113·4	469	113·1
Mean	115·0	Mean	114·0	Mean	112·1	Mean	109·1	Mean	104·9	Mean	100·7
1670 *f. s.*		1710 *f. s.*		1750 *f. s.*		1790 *f. s.*		1830 *f. s.*		1870 *f. s.*	
Mean	115·1	Mean	113·6	Mean	111·5	Mean	108·0	Mean	103·7	Mean	99·6

79. Corrected mean values of K_v for Projectiles with Hemispherical Heads. ($\omega = 534·22$ grains.)

Vel. *f. s.*	Mean K_v	Correction	Corrected K_v	Vel. *f. s.*	Mean K_v	Correction	Corrected K_v
1100	132·6	+0·4	133·0	1730	112·7	0	112·7 −·6
1110	133·2	−0·2	133·0	1740	112·1	0	112·1 −·7
1120	133·7	−0·7	133·0	1750	111·5	+·1	111·4 −·7
1130	134·3	−1·3	133·0	1760	110·8	−·1	110·7 −·8
1140	134·9	−1·9	133·0	1770	109·9	0	109·9 −·9
1150	132·1	+0·9	133·0	1780	109·1	−·1	109·0 −1·0
1160	130·2	+2·8	133·0	1790	108·0	0	108·0 −1·0
......	......	......	......	1800	106·9	+·1	107·0 −1·0
1640	115·6	0	115·6 −·2	1810	106·0	0	106·0 −1·1
1650	115·3	+·1	115·4 −·2	1820	104·9	0	104·9 −1·1
1660	115·0	+·2	115·2 −·2	1830	103·7	+·1	103·8 −1·1
1670	115·1	−·1	115·0 −·3	1840	102·7	0	102·7 −1·1
1680	114·7	0	114·7 −·3	1850	101·6	0	101·6 −1·0
1690	114·3	+·1	114·4 −·4	1860	100·7	−·1	100·6 −1·0
1700	114·0	0	114·0 −·4	1870	99·6	0	99·6
1710	113·6	0	113·6 −·4				
1720	113·2	0	113·2 −·5				

80. Report dated July 8, 1879.

Round	K_v	Round	K_v	Round	K_v	Round	K_v	Round	K_v	Round	K_v
1530 *f. s.*		1590 *f. s.*		1650 *f. s.*		1710 *f. s.*		1770 *f. s.*		1830 *f. s.*	
Mean	173·7	Mean	176·1	Mean	173·4	Mean	172·7	Mean	171·2	Mean	168·4
1540 *f. s.*		1600 *f. s.*		1660 *f. s.*		1720 *f. s.*		1780 *f. s.*		1840 *f. s.*	
		464	165·4	464	165·4	464	165·4	464	166·0	464	166·2
465	186·0	465	182·9	465	178·9	465	174·6	465	171·9	465	170·0
466	162·1	466	170·0	466	175·8	466	177·7	466	175·0	466	166·5
Mean	174·1	Mean	172·8	Mean	173·4	Mean	172·6	Mean	171·0	Mean	167·6
1550 *f. s.*		1610 *f. s.*		1670 *f. s.*		1730 *f. s.*		1790 *f. s.*		1850 *f. s.*	
Mean	174·5	Mean	173·0	Mean	173·3	Mean	172·4	Mean	170·5	Mean	166·7
1560 *f. s.*		1620 *f. s.*		1680 *f. s.*		1740 *f. s.*		1800 *f. s.*		1860 *f. s.*	
		464	165·4	464	165·4	464	165·4	464	166·2	464	166·2
465	185·1	465	181·5	465	177·2	465	173·5	465	171·2	465	169·7
466	164·6	466	172·5	466	177·0	466	177·3	466	172·4	466	161·2
Mean	174·9	Mean	173·1	Mean	173·2	Mean	172·1	Mean	169·9	Mean	165·7
1570 *f. s.*		1630 *f. s.*		1690 *f. s.*		1750 *f. s.*		1810 *f. s.*			
Mean	175·3	Mean	173·2	Mean	173·1	Mean	171·8	Mean	169·4		
1580 *f. s.*		1640 *f. s.*		1700 *f. s.*		1760 *f. s.*		1820 *f. s.*			
		464	165·4	464	165·4	464	165·6	464	166·2		
465	184·2	465	180·3	465	175·7	465	172·7	465	170·5		
466	167·1	466	174·2	466	177·7	466	176·2	466	169·9		
Mean	175·7	Mean	173 3	Mean	172·9	Mean	171·5	Mean	168·9		

81. Corrected mean values of K_v for Projectiles with Flat Heads.
(ω = 534·22 grains.)

Vel. f.s.	Mean K_v	Correction	Corrected K_v	Diff.	Vel. f.s.	Mean K_v	Correction	Corrected K_v	Diff.
1530	173·7	+0·6	174·3	+1	1710	172·7	0	172·7	−1
1540	174·1	+0·3	174·4	0	1720	172·6	0	172·6	−2
1550	174·5	−0·1	174·4	+1	1730	172·4	0	172·4	−3
1560	174·9	−0·4	174·5	0	1740	172·1	0	172·1	−3
1570	175·3	−0·8	174·5	−1	1750	171·8	0	171·8	−3
1580	175·7	−1·3	174·4	−1	1760	171·5	0	171·5	−3
1590	176·1	−1·8	174·3	−1	1770	171·2	0	171·2	−3
1600	172·8	+1·4	174·2	−1	1780	171·0	−0·1	170·9	−4
1610	173·0	+1·1	174·1	−1	1790	170·5	0	170·5	−5
1620	173·1	+0·9	174·0	−1	1800	169·9	+0·1	170·0	−5
1630	173·2	+0·7	173·9	−2	1810	169·4	+0·1	169·5	−6
1640	173·3	+0·4	173·7	−1	1820	168·9	0	168·9	−6
1650	173·4	+0·2	173·6	−1	1830	168·4	−0·1	168·3	−7
1660	173·4	+0·1	173·5	−2	1840	167·6	0	167·6	−8
1670	173·3	0	173·3	−1	1850	166·7	+0·1	166·8	−9
1680	173·2	0	173·2	−2	1860	165·7	+0·2	165·9	
1690	173·1	+0·1	173·0	−1					
1700	172·9	0	172·9	−2					

CHAPTER IV.

DESCRIPTION AND USE OF THE GENERAL TABLES S_v AND T_v.

82. It will be found sufficient for many practical purposes to neglect the effect of gravity and treat the motion of a projectile as if its path was a *straight line*. This will suffice for experimental purposes when it is desired to find the loss of velocity, or the time of flight over a *limited range*, the muzzle velocity being high and the elevation of the gun being small.

In calculating these general tables, for convenience the action of the air upon the projectile has been treated as an *accelerating* force, instead of a retarding force, because the results derived from the use of the Tables are the same in both cases, and the use of proportional parts is more simple in the case of an accelerating force, for then the time, space, and velocity all increase or decrease together.

83. The equation of motion when the accelerating force varies as the *square* of the velocity, is

$$v\frac{dv}{ds} = 2cv^2,$$

or, integrating, $\log_e v = 2cs + C,$

and supposing, when

$$v = 0, \quad t = 0, \quad v = V,$$

then $\log_e \frac{v}{V} = 2cs,$

or $$\frac{d^2}{w}s = \frac{1}{2c}\frac{d^2}{w}\log_e \frac{v}{V} = \frac{(1000)^2}{k}\log_e \frac{v}{V} \quad \text{...........(1)},$$

for $$2c = 2bv = K\frac{d^2}{w}\frac{v}{(1000)^3} = \left(K\frac{v}{1000}\right)\frac{d^2}{w}\left(\frac{1}{1000}\right)^2$$
$$= k\frac{d^2}{w}\left(\frac{1}{1000}\right)^2 \text{ suppose.}$$

For velocities of ogival-headed shot below 820 *f. s.*, $k = 60{\cdot}5$, which gives

$$\frac{d^2}{w}s = 38059 \log_{10}\left(\frac{v}{V}\right),$$

and for velocities of spherical shot below 840 *f. s.*, $k = 118{\cdot}3$, which gives

$$\frac{d^2}{w}s = 19464 \log_{10}\left(\frac{v}{V}\right).$$

84. Again $$\frac{d^2s}{dt^2} = \frac{dv}{dt} = 2cv^2,$$

and integrating

$$\frac{1}{V} - \frac{1}{v} = 2ct,$$

or $$\frac{d^2}{w}t = \frac{1}{2c}\frac{d^2}{w}\left(\frac{1}{V} - \frac{1}{v}\right) = \frac{1000}{k}\left(\frac{1000}{V} - \frac{1000}{v}\right) \text{........(2).}$$

85. The equation of motion, when the accelerating force varies as the *cube* of the velocity, is

$$v\frac{dv}{ds} = 2bv^3,$$

and integrating

$$\frac{1}{V} - \frac{1}{v} = 2bs,$$

or $$\frac{d^2}{w}s = \frac{1}{2b}\frac{d^2}{w}\left(\frac{1}{V} - \frac{1}{v}\right) = \frac{(1000)^2}{K}\left\{\left(\frac{1000}{V}\right) - \left(\frac{1000}{v}\right)\right\}\text{...(3).}$$

86. Again $$\frac{d^2s}{dt^2} = \frac{dv}{dt} = 2bv^3.$$

Integrating $$\frac{1}{2V^2} - \frac{1}{2v^2} = 2bt$$

or $$\frac{d^2}{w}t = \frac{1}{4b}\frac{d^2}{w}\left(\frac{1}{V^2} - \frac{1}{v^2}\right) = \frac{500}{K}\left\{\left(\frac{1000}{V}\right)^2 - \left(\frac{1000}{v}\right)^2\right\} \text{.....(4).}$$

Also, since $$\frac{1}{V} - \frac{1}{v} = 2bs,$$

therefore $$\frac{dt}{ds} = \frac{1}{V} - 2bs,$$

and integrating $$t = \frac{s}{V} - bs^2 \text{.................................}(5).$$

In calculating general tables formulæ (1) and (2), or (3) and (4) may be used so long as k or K respectively remain constant. But when k, or K varies with the velocity, its value will require to be often changed, so that k_v or K_v may be supposed to remain constant through a change of velocity, say from $(v-5)$ to $(v+5)$ *f.s.* Intermediate values can afterward be found by interpolation. In this way General Tables XXIII. to XXVI. have been calculated.

87. The velocity of a projectile is generally found by measuring the time t in seconds occupied by the projectile in passing over a range of s feet, and dividing the number of feet by the number of seconds, the velocity in feet per second at the middle point of the range is approximately found in general. But where the accelerating or retarding force varies as the *cube* of the velocity, this is exactly true. For

$$\frac{1}{v} = \frac{1}{V} - 2bs,$$

and if v' be the velocity of the projectile at the distance $\frac{1}{2}s$, then

$$\frac{1}{v'} = \frac{1}{V} - bs.$$

But the measured velocity

$$= \frac{\text{space in feet}}{\text{time in seconds}}$$

$$= \frac{s}{\frac{s}{V} - bs^2} = \frac{1}{\frac{1}{V} - bs} = v'$$

= the velocity at the middle point of the range s.

88. Special tables of remaining velocities were given for elongated projectiles with various forms of heads in my Report

of 1866[1]; also for 7, 8 and 9-inch ogival-headed projectiles in the Report of 1868[2]; and for all the service spherical projectiles in the Report of 1869[3]; and also for ogival-headed projectiles fired from all the Service guns[4].

89. Suppose we have two projectiles of *similar external forms*, whose diameters are d, d'; and weights w, w' respectively. Then by equation (3), we have

$$\frac{d^2}{w} s = (1000)^3 \int_v^V \frac{dv}{Kv^2} = \frac{d'^2}{w'} s',$$

for K, v, and V are the same for both projectiles. Hence if we have calculated a table of ranges s', in which a projectile (d', w') loses any given velocity, from this table we can calculate the range s, in which another *similarly shaped* projectile (d, w) will lose the same given velocity, for then

$$s = s' \frac{d'^2}{w'} \div \frac{d^2}{w}.$$

This led me in the first instance to calculate general tables where $\frac{d'^2}{w'} = 1$, which were first published in 1871 for both spherical and ogival-headed projectiles[5].

In the same way it may be shown that

$$t = t' \frac{d'^2}{w'} \div \frac{d^2}{w}.$$

The corresponding General Tables were first published in 1872[6].

90. The variation in the density of the air must greatly affect the motion of projectiles, as the resistance of the air is assumed to vary as its density. As already explained the coefficients for both elongated and spherical projectiles have now been calculated for such a density that one cubic foot of dry air would weigh 534·22 grains. This change has had the effect of increasing the values of K given in the Report of 1868 by about 0·7 per cent. It is evident that, when any calculation of an experiment has to be made by the tables and methods given in this work, it will be

[1] Reports, &c. 1865—1870, p. 15. [2] Ib. pp. 49, 50. [3] Ib. p. 116.
[4] Remaining velocities, &c. 1871, and Proceedings of the R. A. Inst. VII. p. 337.
[5] Remaining velocities, pp. 47, 48, and Proceedings of the R. A. Inst. VII. pp. 391, 392. [6] Ib. VIII. p. 4.

necessary to introduce corrections in order to adapt the results obtained to the density of the air on the day of that experiment.

91. Those who use French measures generally adopt as their standard, such a density of the air that one cubic metre of dry air would weigh 1·206 kil., which gives the weight of a cubic foot of air 526·94 grains, or nearly 527 grains. Hence it appears that the English coefficients ought to be numerically 1·37 per cent. greater than the French coefficients; while the English coefficients of 1868 would exceed the French by about 0·7 per cent. But when a proper correction has been introduced to adapt the tables to the density of the air on any particular day then the results arrived at ought to be the same, whatever be the table made use of.

92. The corrections of the coefficients k and K, for the density of the air, are applied as follows. On any particular day, the weight of a cubic foot of air is easily found from Glaisher's Tables, when observations have been made with the Barometer and with the dry and wet bulb Thermometers. Suppose that τ denotes the weight in grains of a cubic foot of air on that day, divided by 534·22 the standard weight in grains, then τ will be a constant for that round, provided the shot does not rise high enough to have its resistance sensibly affected by the diminishing density of the air. As k and K vary as the density of the air, they will have the values τk and τK adapted to the density of air on that particular day. By formula (4) we have

$$\frac{dt}{dv}=\frac{1}{2bv^3},$$

or

$$\frac{d^2}{w}t=(1000)^3\int_V^v\frac{dv}{K_v v^3}=T_v-T_V$$

$$=\text{difference of two tabular numbers.}$$

But on the day above referred to every value of K_v must be replaced by τK_v, where τ is constant, and K_v is generally variable, then

$$\frac{d^2}{w}t=(1000)^3\int_V^v\frac{dv}{\tau K_v v^3}=\frac{(1000)^3}{\tau}\int_V^v\frac{dv}{K_v v^3},$$

or

$$\tau\frac{d^2}{w}t=(1000)^3\int_V^v\frac{dv}{K_v v^3}=T_v-T_V$$

$$=\text{difference of the same tabular numbers as before.}$$

And in the same way it may be proved that

$$\tau \frac{d^2}{w} s = \text{difference of tabular numbers}$$

$$= S_v - S_V.$$

93. Suppose now a change to be made in the *form* of the head of an elongated shot, and that it is found by experiment that it is necessary for this particular form of head to change the values of K obtained from experiments made with ogival-headed shot struck with a radius of one diameter and a half to κK, where κ is constant.

Further, suppose that we are experimenting with a gun that gives a degree of steadiness different from that of the average of the experimental guns, so as to require coefficients σK to be used instead of K, where σ is a constant.

Then as before, we shall find

$$\tau\kappa\sigma \frac{d^2}{w} t = T_v - T_V,$$

and

$$\tau\kappa\sigma \frac{d^2}{w} s = S_v - S_V.$$

In order to introduce these corrections into the results obtained by the use of the General Tables, or into the calculation of trajectories, we have only to find the value of $\tau\kappa\sigma \frac{d^2}{w}$ and use that value instead of $\frac{d^2}{w}$.

94. A table has been calculated so that, on referring to it with the readings of the Barometer and Thermometer, the value of $\log \tau$ can be obtained directly on the supposition that the air is $\frac{2}{3}$ds saturated with moisture with sufficient exactness for all practical purposes[1]. In calculating this Table XX., the weight in grains of a cubic foot of air $\frac{2}{3}$ds saturated with moisture, under a pressure of 29 inches of mercury, was found by Glaisher's Tables for each degree of temperature. Each of these numbers was divided by 534·22 the number of grains in the weight of the standard cubic foot of air,

[1] Proceedings of the R. A. Inst. XIII. p. 348.

and the resulting values of τ were adapted to heights 15 to 31 inches of the barometer.

95. Table XXI. gives the values of $\log \tau$ corresponding to various heights. In calculating this table the simple formula

$$z = c' \log \frac{h}{h'}$$

was made use of, where h denotes the height of the barometer in inches at the lower station, h' that at the upper station, and z the difference in feet of the vertical heights of the two stations. Here the force of gravity, and the temperature of the air are supposed constant. The table has been calculated in the following manner.

$$\log \tau = \log \frac{h'}{h} = -\frac{z}{c'}$$

$$= N - \frac{100 \times n}{c'} = 0{\cdot}0729 - \frac{100 \times n}{64110} = 0{\cdot}0729 - 0{\cdot}00156n;$$

$n = 0$, $\log \tau = 0{\cdot}0729$; $n = 1$, $\log \tau = 0{\cdot}0729 - 0{\cdot}00156 = 0{\cdot}07134$;

$n = 2$, $\log \tau = 0{\cdot}0729 - 0{\cdot}00156 \times 2 = 0{\cdot}06978$, &c., &c.

96. From readings of the barometer, &c. the value of $\log \tau$ is found by Table XX. at the place of observation. On referring to Table XXI. suppose this value of $\log \tau$ is found opposite the height H feet; then the tabular number found opposite $H + z$ feet, will be the approximate value of $\log \tau$ at a place z feet higher than the place of observation. Table XXI. may be used when French measures are employed, if the heights expressed in feet in the table are converted into metres.

97. The resistance of the air to a projectile of weight w and d inches in diameter moving with the velocity v is equal to

$$2b \frac{w}{g} v^3 = \frac{K}{g} d^2 \left(\frac{v}{1000}\right)^3.$$

In this way Table XXII. has been calculated for spherical and ogival-headed projectiles.

98. General tables have been calculated to connect velocity and range, and velocity and time of flight for both spherical and ogival-headed projectiles. See Tables XXIII. to XXVI. Similar

tables for French measures have also been given. See Tables XXX. to XXXIII. In the latter case we denote the diameter of the shot in centimetres by a; its weight in kilogrammes by p, and the force of gravity by g metres per second.

EXAMPLES OF THE USE OF THE GENERAL TABLES.

99. (1) Suppose it was asked in what range and time an 11·52-inch ogival-headed shot weighing 600 lbs. would have its velocity reduced from 1420 to 1250 *f. s.* Here

$$d^2 \div w = (11{\cdot}52)^2 \div 600 = 0{\cdot}2212.$$

Let s denote the required range, and t the time of flight, then

$$(\omega = 534{\cdot}22 \text{ grains})$$

$$\frac{d^2}{w} s = 0{\cdot}2212 s = S_{1420} - S_{1250} = 41638{\cdot}4 - 40750{\cdot}8 = 887{\cdot}6,$$

and therefore $\quad s = 887{\cdot}6 \div 0{\cdot}2212 = 4013 \text{ feet},$

and $\quad \frac{d^2}{w} t = 0{\cdot}2212 t = 160{\cdot}9015 - 160{\cdot}2344 = 0{\cdot}6671,$

and therefore $\quad t = 0{\cdot}6671 \div 0{\cdot}2212 = 3''{\cdot}016.$

(2) Calculate the same example with the tables adapted for French measures. Here

$$\mathrm{a} = 11{\cdot}52 \text{ in.} = 29{\cdot}26 \text{ cm.};$$

$$\mathrm{p} = 600 \text{ lbs.} = 272{\cdot}16 \text{ kgs.}$$

$$1420 \, f.\, s. = 432{\cdot}81 \text{ m. s.},$$

$$1250 \, f.\, s. = 381{\cdot}0 \text{ m. s.},$$

and $\quad \mathrm{a}^2 \div \mathrm{p} = 3{\cdot}146 \quad (\omega = 527 \text{ grains}),$

then $\quad \frac{\mathrm{a}^2}{\mathrm{p}} s' = \mathfrak{S}_{432{\cdot}81} - \mathfrak{S}_{381} = 183042 - 179141 = 3901,$

or $\quad s' = 3901 \div 3{\cdot}146 = 1240 \text{ metres} = 4068 \text{ feet},$

and $\quad \frac{\mathrm{a}^2}{\mathrm{p}} t' = \mathfrak{T}_{432{\cdot}81} - \mathfrak{T}_{381} = 2320{\cdot}54 - 2310{\cdot}90 = 9{\cdot}64,$

or $\quad t' = 9{\cdot}64 \div 3{\cdot}146 = 3''{\cdot}065.$

As we have used the standard density for which each table was adapted, in order to make the results comparable, by (91) we must reduce the French results by 1·37 per cent. Then the corrected value of s' $= 4068 - 55 = 4013$ feet;

and the corrected value of t'

$$= 3''\cdot065 - 0''\cdot041 = 3''\cdot024.$$

(3) Suppose we wish to find the time of flight of a spherical projectile ($w = 163\cdot5$ lbs., $d = 10\cdot4$ in.) over a range of 5000 feet, the muzzle velocity being 1988 *f.s.* and $\omega = 534\cdot22$ grains. Here $d^2 \div w = 0\cdot6615$. In the first place we must find the velocity v at the end of the range of 5000 feet. Here by Table XXIII.

$$S_v = S_{1988} - \frac{d^2}{w} 5000 = 11383\cdot5 - 3307\cdot5 = 8076\cdot0 = S_{1045\cdot7}.$$

Therefore the terminal velocity

$$v = 1045\cdot7 \, f.s.$$

We must now find in what time the velocity of the same shot would be reduced from 1988 *f.s.* to 1045·7. By Table XXIV.

$$\frac{d^2}{w} t = 0\cdot6615t = T_{1988} - T_{1045\cdot7} = 19\cdot4388 - 17\cdot0755 = 2\cdot3633.$$

Therefore $t = 2\cdot3633 \div 0\cdot6615 = 3''\cdot572$ the required time of flight.

(4) We will now solve the same problem using French measures:

$\mathfrak{a}$ = diameter of spherical projectile = 10·4 in. = 26·42 c.m.;

$\mathfrak{p}$ = its weight = 163·5 lbs. = 74·16 kgs.;

5000 feet = 1524 metres;

1988 *f.s.* = 605·93 m.s.,

and $\omega = 527\cdot0$ grains.

This gives $\tau = 1\cdot0137$.

By Table XXX. we find

$$\mathfrak{S}_{\mathfrak{b}} = \mathfrak{S}_{605\cdot9} - \frac{\mathfrak{a}^2}{\mathfrak{p}} \tau s = 50043 - \frac{(26\cdot42)^2}{74\cdot16} \times 1\cdot0137 \times 1524$$

$$= 50043 - 14540 = 35503 = \mathfrak{S}_{318\cdot7},$$

$$\therefore \ \mathfrak{b} = 318\cdot7 \text{ m.s.} = 1045\cdot6 \text{ f.s.}$$

Next to find in what time t the velocity of the given spherical shot would be reduced from 605·93 to 318·7 m.s. By Table

$$\frac{\mathfrak{a}^2}{\mathfrak{p}} \tau t = \mathfrak{T}_{605\cdot93} - \mathfrak{T}_{318\cdot7} = 280''\cdot343 - 246''\cdot27 = 34''\cdot073,$$

therefore $$t = \frac{34''\cdot073}{1\cdot0137} \times \frac{74\cdot16}{(26\cdot42)^2} = 3''\cdot571$$

very nearly as before where $\omega = 534\cdot22$ grs.

100. The General Tables calculated for ogival-headed projectiles may be used to calculate range and time of flight for elongated projectiles having other *forms* of head, provided κ the ratio of their coefficients of resistance be known. In this case we shall have by (93)

$$\frac{d^2}{w}\kappa s = S_v - S_V \text{ and } \frac{d^2}{w}\kappa t = T_v - T_V.$$

As an example we will take the three rounds (70) of flat-headed projectiles: Rounds 464—6, where $w = 70$ lbs., $d = 6$ ins.; Barometer 30·4 ins.; Dry bulb thermometer 42° F., Wet do. 41° F. These observations give the weight of a cubic foot of air by Glaisher's Tables 561·2 grains on the day of experiment, so that $\tau = 561\cdot2 \div 534\cdot22 = 1\cdot051$. Or, using the Table XX., we find directly $\log \tau = 0\cdot0160 + \cdot0057 = 0\cdot0217$ which gives $\tau = 1\cdot051$. The screens were 150 feet apart. The average of the times at which the three shots passed the third screen was 0″·16011; and the ninth screen was 0″·69015. Thus the mean time occupied by the shot in passing from the third to the ninth screen, or over 900 feet, was found by experiment to be 0″·5300. The third screen was passed with a mean velocity 1827·7 *f.s.*, and the ninth screen with a mean velocity of 1585 *f.s.* Referring to the Table XIV. of values of K for flat-headed shot we may assume $\kappa_2 = 2\cdot06$ for the above range of velocity.

Then $$\frac{d^2}{w}\kappa_2\tau = \frac{36}{70} \times 2\cdot06 \times 1\cdot051 = 1\cdot1134,$$

and by Table XXVI.

$$\frac{d^2}{w}\kappa_2\tau t = T_{1827\cdot7} - T_{1585} = 161''\cdot9892 - 116''\cdot3993 = 0''\cdot5899,$$

therefore $$t = \frac{0''\cdot5899}{1\cdot1134} = 0''\cdot530,$$

which agrees with experiment. Again, by Table XXV.,

$$\frac{d^2}{w}\kappa_2\tau s = S_{1827\cdot7} - S_{1585} = 43388\cdot7 - 42384\cdot8 = 1003\cdot9,$$

therefore $$s = \frac{1003\cdot9}{1\cdot1134} = 901\cdot6 \text{ feet instead of } 900 \text{ feet.}$$

101. We will next take the three rounds 467—9 of hemispherical-headed projectiles (70), fired on a day when the height of the barometer was 30·25 inches; dry-bulb thermometer 45° F., and the wet ditto 42° F. These give $\tau = 1{\cdot}039$. The mean times of the shot passing the third and ninth screens were 0″·15923 and 0″·66713 respectively, giving 0″·5079 as the mean time, found by experiment, occupied by the projectiles in passing from the third to the ninth screen, or over 900 feet. Also the mean velocity at the third screen was 1856 *f. s.*; and 1692 *f. s.* at the ninth screen. Referring to the Table XIII. of values of K for hemispherical-headed projectiles, it will be found that $\kappa_1 = 1{\cdot}38$ between the above specified velocities.

Then

$$\frac{d^2}{w}\kappa_1\tau = \frac{36}{70} \times 1{\cdot}38 \times 1{\cdot}039 = 0{\cdot}7374,$$

and, by Table XXVI.,

$$\frac{d^2}{w}\kappa_1\tau t = T_{1856} - T_{1692} = 162''{\cdot}0495 - 161''{\cdot}6766 = 0''{\cdot}3729,$$

therefore $$t = \frac{0''{\cdot}3729}{0{\cdot}7374} = 0''{\cdot}506.$$

Again, by Table XXV.

$$\frac{d^2}{w}\kappa_1\tau s = S_{1856} - S_{1692} = 43499{\cdot}7 - 42838{\cdot}9 = 660{\cdot}8.$$

Therefore $$s = \frac{660{\cdot}8}{0{\cdot}7374} = 896{\cdot}1 \text{ feet instead of 900 feet.}$$

In the above two cases we have the advantage of using the values of κ_1 and κ_2 derived from the examples we have calculated. But the tables used in the calculations were derived from experiments made with *ogival*-headed projectiles.

102. In order to show clearly in what way the results of experiments were made available for the public service, it seems advisable to give, not only references, but *specimens* as well, of the useful ballistic tables adapted for practical use, which were published by me from time to time.

103. In the report of the results obtained by the employment of elongated projectiles with various forms of heads (1866), tables of remaining velocities were given for each form of projectile for

intervals of 100 feet in range[1]. The following is an abridgment of the two tables for solid ogival-headed experimental projectiles struck with radii of one and of two diameters, compared with similar tables calculated by the accompanying general tables (1889) derived from experiments made with ogival-headed shot struck with a radius of one diameter and a half.

$\frac{d^2}{w} = 0.5584$				$\frac{d^2}{w} = 0.5738$		
Distance	1 diam. 1866	$1\frac{1}{2}$ diam. 1889	Diff.	2 diam. 1866	$1\frac{1}{2}$ diam. 1889	Diff.
feet	f. s.	f. s.		f. s.	f. s.	
0	1500·0	1500·0	0	1500·0	1500·0	0
500	1434·3	1439·3	+5·0	1435·6	1437·7	+2·1
1000	1374·2	1381·2	+7·0	1376·4	1378·1	+1·7
1500	1318·9	1326·2	+7·3	1322·0	1321·9	−0·1
2000	1267·9	1274·7	+6·8	1271·7	1269·2	−2·6
2500	1220·7	1226·8	+6·1	1225·1	1220·5	−4·6
3000	1176·9	1182·4	+5·5	1181·8	1175·4	−6·4
3500	1136·1	1141·2	+5·1	1141·4	1133·5	−7·9
4000	1098·1	1102·8	+4·7	1103·7	1094·9	−8·8
4500	1062·6	1068·8	+6·2	1068·4	1061·2	−7·3

This comparison exhibits the value of the early experiments, for the calculated velocities of the ogival-headed projectiles struck with a radius of one diameter and a half, are generally less than those given for heads struck with a radius of two diameters, and greater than those given by a head struck with a radius of one diameter, as they ought to be.

104. In the Report on the resistance of the air to the motion of ogival-headed projectiles (July 23, 1868), tables were given of the remaining velocities of ogival-headed service shot when fired from 7, 8 and 9-inch M. L. guns[2], the projectiles being supposed to move under the action of the resistance of the air only. These tables were shortly afterwards reprinted in the *Proceedings* of the R. A. Institution[3], and in Colonel Owen's *Modern Artillery*[4]. These are the tables referred to by General Mayevski in his Treatise on *Balistique Extérieure*, which matter will require to

[1] Reports, &c. 1865—1870, p. 15.
[2] Ib. p. 49.
[3] Notes, 1868, p. 69.
[4] 1871, p. 430.

be noticed hereafter. The following is a copy of the complete table for the 7-inch gun, omitting decimals, where

$d = 6{\cdot}92$ in. $= 17{\cdot}58$ c. m.; $w = 115$ lbs. $= 52{\cdot}2$ kil.; $d^2 \div w = 0{\cdot}4164$.

Distance	0	100	200	300	400	500	600	700	800	900
feet	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
0	1717	1706	1695	1685	1674	1663	1653	1643	1633	1623
1000	1613	1603	1593	1584	1575	1565	1556	1546	1537	1527
2000	1518	1509	1499	1490	1481	1472	1463	1455	1446	1437
3000	1428	1419	1410	1402	1393	1385	1377	1368	1360	1352
4000	1344	1336	1328	1320	1312	1304	1296	1288	1281	1273
5000	1266	1259	1252	1244	1237	1230	1223	1216	1209	1203
6000	1196	1189	1183	1176	1170	1164	1157	1151	1145	1140
7000	1134	1129	1123	1118	1113	1107	1102	1097	1091	1086
8000	1081	1076	1071	1066	1061	1056	1052	1048	1045	1041
9000	1038	1034	1031	1028	1024	1021	1018	1015	1011	1008
10000	1005	1002	999	996	992	989	986	983	980	977

105. Here it must be pointed out that the coefficients, by which the above table was calculated in 1868, were revised in the following year, as explained at the conclusion of the report on the experiments made with spherical projectiles as follows: "In order, however, to obtain a more satisfactory table of values of $2000b\,\frac{w}{d^2}$" (for ogival-headed projectiles) "we have commenced the re-calculation of the times of passing each screen expressed to *five* places of decimals of a second. In this manner we shall obtain a table of average values of $2000b'\,\frac{w}{d^2}$ derived from all the rounds of *elongated* shot fired, just as we have obtained a table of values of $2000b'\,\frac{w}{d^2}$ for *spherical* shot[1]." These results were printed shortly afterwards and they entirely superseded the first table of coefficients[2], although the alteration was not great.

Also in the Report on experiments made with spherical projectiles, the coefficients obtained by experiment were used in a manner similar to the above to calculate the remaining velocities of spherical projectiles fired from the service guns[3]. The same were reprinted in Tables of Remaining Velocities[4], &c.: in Colonel Owen's *Modern Artillery*[5]; and in the *Proceedings* of the R.A. Institution[6]. The following is an abridgment of this Table.

[1] Reports, &c., 1865—1870, p. 65.
[2] Ib. pp. 123—152.
[3] Ib. p. 116.
[4] 1871, p. 35.
[5] 1871, p. 432.
[6] 1871, p. 379.

"Table showing the Velocities of Spherical Solid Shot for the "undermentioned Guns at intervals of 100 feet, supposing the "Shot to move in a straight line, subject only to the Resistance of "the Air." Report, dated Feb. 13, 1869.

Gun	$d^2 \div w$	Gun	$d^2 \div w$	Gun	$d^2 \div w$
15-in.	·4898	32-pr.	1·2161	9-pr.	1·8422
150-pr.	·6615	24-pr.	1·3373	6-pr.	2·1218
100-pr.	·7766	18-pr.	1·4648	3 pr.	2·6564
68-pr.	·9487	12-pr.	1·6696		

Distance	15-in.	150-pr.	100-pr.	68-pr.	32-pr.	24-pr.	18-pr.	12-pr.	9-pr.	6-pr.	3-pr.
feet	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*	*f. s.*
0	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
100	2079	2072	2067	2059	2048	2043	2038	2030	2022	2011	1990
200	2058	2044	2033	2019	1998	1988	1978	1962	1947	1926	1886
300	2037	2016	2001	1980	1948	1935	1920	1896	1875	1845	1788
400	2017	1988	1970	1942	1900	1883	1863	1833	1806	1768	1696
1500	1805	1714	1654	1571	1449	1402	1349	1272	1215	1126	994
1600	1787	1691	1628	1541	1415	1366	1311	1233	1175	1086	957
1700	1769	1668	1603	1512	1381	1331	1275	1196	1137	1049	925
1800	1752	1645	1578	1484	1349	1297	1241	1161	1101	1015	897
1900	1735	1623	1553	1456	1318	1265	1208	1128	1068	984	873
2000	1717	1601	1529	1429	1288	1234	1176	1097	1036	956	
2100	1700	1580	1505	1403	1258	1204	1146	1068	1007	930	
2200	1683	1559	1482	1377	1230	1175	1117	1040	980	906	
2300	1667	1538	1459	1352	1203	1147	1090	1014	955	884	
2400	1650	1518	1437	1327	1176	1121	1065	990	932		
2500	1633	1498	1415	1303	1151	1096	1041	968	911		
2600	1617	1479	1394	1280	1127	1072	1018	946	892		
2700	1601	1459	1373	1257	1104	1050	997	926			
2800	1585	1440	1352	1235	1082	1029	977	907			
2900	1570	1422	1331	1214	1061	1009	958	889			
3000	1554	1403	1311	1193	1041	990	940	871			
......	......	......	......	......	......	......	......				
3500	1479	1316	1219	1097	955	906	857				
......	......	......	......	......	......						
4000	1409	1235	1136	1019	884						
......	......	......	......	......							
4500	1343	1163	1065	954							
......	......	......	......	......							
5000	1281	1098	1005	898							
......	......	......	......								
5500	1223	1042	952								
......	......	......	......								
6000	1170	993	906								
......	......	......									
6500	1120	950									
......	......	......									
7000	1076	910									
......	......										
7500	1036										
......	......										
8000	999										

106. By the help of the Table given for the 7-inch gun, where $d'^2 \div w' = 0{\cdot}4164$, we may find in what range the velocity of a 10-inch ogival-headed projectile where $d^2 \div w = 0{\cdot}2424$, will be reduced from 1700 to 1300 f. s. and from 1300 to 1100 f. s. Referring to the Table (104), it is found that the 7-inch shot has its velocity reduced from 1700 to 1300 f. s. in a range

$$4550 - 155 \text{ feet} = 4395 \text{ feet}:$$

therefore the 10-inch shot would by (88) have its velocity reduced in like manner in a range

$$4395 \times (d'^2 \div w') \div (d^2 \div w) = 4395 \times 0{\cdot}4164 \div 0{\cdot}2424$$
$$= 7550 \text{ feet} = 2517 \text{ yards}.$$

In the same way it is found from the Table that the velocity of the 7-inch shot is reduced from 1300 to 1100 f. s. in a range $7640 - 4550 = 3090$ feet; therefore the 10-inch shot would suffer the same reduction of velocity in a range

$$3090 \times 0{\cdot}4164 \div 0{\cdot}2424 = 5307 \text{ feet} = 1769 \text{ yards};$$

where $\omega = 530{\cdot}6$ grains.

The same law holds good for spherical projectiles. From the Table, (105), it appears that the 15-inch spherical projectile has its velocity reduced from 2100 to 1409 f. s. in a range of 4000 feet, where $d'^2 \div w' = 0{\cdot}4898$. From this, we find that the velocity of the 100-pr. projectile, where $d^2 \div w = 0{\cdot}7766$, would have its velocity reduced in like manner from 2100 to 1409 f. s. in a range

$$4000 \times 0{\cdot}4898 \div 0{\cdot}7766 = 2523 \text{ feet}.$$

From the Special Table for the 100-pr. we find 2528 feet.

107. The following are specimens of my earliest General Tables for spherical and ogival-headed projectiles, which connect velocity and space, and velocity and time.

"A General Table for facilitating the Calculation of the Range "corresponding to a given loss of Velocity of any SPHERICAL "SHOT[1]." 1871.

Distance	0	10	20	30	40	50	60	70	80	90
feet	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*
0	2100·0	2095·6	2091·3	2086·9	2082·6	2078·3	2074·0	2069·6	2065·3	2061·0
100	2056·7	2052·5	2048·2	2043·9	2039·7	2035·5	2031·2	2027·0	2022·8	2018·6
200	2014·4	2010·2	2006·0	2001·9	1997·7	1993·6	1989·4	1985·3	1981·2	1977·1
300	1973·0	1968·9	1964·8	1960·7	1956·7	1952·6	1948·6	1944·6	1940·5	1936·5
400	1932·5	1928·5	1924·5	1920·5	1916·6	1912·6	1908·7	1904·7	1900·8	1896·9
......	......	......	......	......	......	......	......	......	......	......
1600	1511·3	1508·3	1505·2	1502·2	1499·2	1496·2	1493·2	1490·2	1487·2	1484·2
1700	1481·2	1478·3	1475·3	1472·3	1469·4	1466·4	1463·5	1460·6	1457·7	1454·8
1800	1451·9	1449·0	1446·1	1443·2	1440·3	1437·5	1434·6	1431·7	1428·9	1426·1
1900	1423·2	1420·4	1417·6	1414·8	1412·0	1409·2	1406·4	1403·6	1400·8	1398·1
2000	1395·3	1392·6	1389·8	1387·1	1384·4	1381·6	1378·9	1376·2	1373·5	1370·8
......	......	......	......	......	......	......	......	......	......	......
4800	889·4	888·3	887·2	886·1	885·0	883·9	882·9	881·8	880·7	879·7
4900	878·6	877·5	876·5	875·4	874·3	873·3	872·2	871·2	870·1	869·1

108. "A General Table for facilitating the Calculation of "the Range corresponding to a given loss of Velocity of any "ELONGATED SHOT (Ogival Head)[2]." 1871.

Distance	0	10	20	30	40	50	60	70	80	90
feet	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*	*f.s.*
0	1700·0	1697·5	1695·1	1692·7	1690·3	1687·9	1685·5	1683·2	1680·8	1678·4
100	1676·0	1673·7	1671·3	1668·9	1666·6	1664·2	1661·9	1659·5	1657·2	1654·8
200	1652·5	1650·2	1647·9	1645·6	1643·3	1640·9	1638·6	1636·3	1634·0	1631·7
300	1629·4	1627·1	1624·8	1622·5	1620·2	1617·9	1615·6	1613·3	1611·1	1608·8
400	1606·5	1604·2	1601·9	1599·7	1597·4	1595·1	1592·8	1590·6	1588·3	1586·0
......	......	......	......	......	......	......	......	......	......	......
2000	1275·9	1274·1	1272·3	1270·6	1268·8	1267·1	1265·3	1263·6	1261·9	1260·1
2100	1258·4	1256·7	1255·0	1253·3	1251·6	1249·9	1248·2	1246·5	1244·8	1243·1
2200	1241·5	1239·8	1238·1	1236·4	1234·8	1233·1	1231·5	1229·8	1228·2	1226·5
2300	1224·9	1223·3	1221·6	1220·0	1218·4	1216·8	1215·2	1213·6	1212·0	1210·4
2400	1208·8	1207·2	1205·6	1204·0	1202·4	1200·9	1199·3	1197·7	1196·2	1194·6
......	......	......	......	......	......	......	......	......	......	......
5400	921·7	921·1	920·6	920·0	919·5	918·9	918·3	917·8	917·2	916·7
5700	905·4	904·8	904·3	903·8	903·3	902·7	902·2	901·7	901·1	900·7

The above Tables were to be used as follows. "Let an "elongated projectile of 400 lbs. be fired from a 10-inch gun with

[1] Remaining Velocity, &c. 1871, p. 47; and Proceedings of the R. A. Inst. VII. p. 391.

[2] Remaining Velocity, &c. 1871, p. 48; and Proceedings of the R. A. Inst. VII. p. 392.

"an initial velocity of 1270 f. s., and let it be required to find what "would be the velocity at a distance of 1000 yards = 3000 feet. "Here $d^2 \div w = 0{\cdot}246$ and the reduced range $= 3000 \times 0{\cdot}246 = 738$ "feet. Referring to General Table, the initial velocity 1270 f. s. is "found corresponding to a distance 2033 feet, to which, adding "the *reduced* range 738 feet, we get 2771 feet, and at this distance "the velocity = 1152·6 f. s., which is the velocity which the 400-lb. "shot would have at 1000 yards from the gun[1]."

109. "A General Table for facilitating the Calculation of the "Time corresponding to a given loss of Velocity of any Spherical "Shot[2]." 1872.

v	9	8	7	6	5	4	3	2	1	0
f. s.	"	"	"	"	"	"	"	"	"	"
189	0·0013	·0027	·0040	·0054	·0067	·0081	·0094	·0108	·0121	·0135
188	·0148	·0162	·0175	·0189	·0203	·0216	·0230	·0244	·0257	·0271
...	....	......	......	......	......	......	......	......	......	......
123	1·4056	·4090	·4125	·4160	·4195	·4230	·4265	·4300	·4336	·4371
122	·4407	·4442	·4478	·4513	·4549	·4585	·4620	·4656	·4692	·4728
121	·4764	·4800	·4836	·4873	·4909	·4945	·4982	·5018	·5055	·5092
120	·5129	·5166	·5203	·5240	·5277	·5315	·5352	·5390	·5428	·5465
...	....	......	......	......	......	......	......	......	......	......
90	3·3280	·3377	·3474	·3571	·3668	·3766	·3864	·3962	·4060	·4159

110. "A General Table for facilitating the Calculation of the "Time corresponding to a given loss of Velocity of any Elongated "Shot (Ogival Head)[3]." 1872.

v	9	8	7	6	5	4	3	2	1	0
f. s.	"	"	"	"	"	"	"	"	"	"
169	0·0024	·0049	·0073	·0098	·0122	·0146	·0171	·0195	·0220	·0244
168	·0269	·0294	·0318	·0343	·0368	·0393	·0418	·0443	·0468	·0493
167	·0518	·0543	·0569	·0594	·0619	·0644	·0669	·0695	·0720	·0745
...	....	......	......	......	......	......	......	......	......	......
136	·9861	·9898	·9935	·9972	·0009	·0047	·0084	·0121	·0159	·0196
135	1·0234	·0272	·0309	·0347	·0385	·0423	·0461	·0499	·0537	·0575
134	·0614	·0652	·0690	·0729	·0767	·0806	·0844	·0883	·0922	·0960
...	....	......	......	......	......	......	......	......	......	......
113	2·0827	·0890	·0953	·1016	·1079	·1143	·1207	·1271	·1335	·1399
112	·1464	·1528	·1593	·1658	·1723	·1789	·1855	·1921	·1987	·2053
111	·2120	·2187	·2254	·2321	·2388	·2456	·2524	·2592	·2661	·2729
...	....	......	......	......	......	......	......	......	......	......
70	10·8975	·9412	·9850	·0290	·0732	·1176	·1622	·2070	·2520	·2972

[1] Remaining Velocity, &c., p. 31; and Proceedings of the R. A. Inst. VII. p. 375, 1871.

[2] Proceedings of the R. A. Inst. VIII. p. 4. [3] Ib. p. 6.

The following instructions were given for the use of the above Tables, 1872.

EXAMPLE. "Suppose it was required to find by the help "of the General Table in what time the velocity of a 700-lb. "elongated shot would be reduced from 1344 to 1129 f. s. "Here $d = 11{\cdot}52$ inches and $d^2 \div w = {\cdot}1896$. By Table we find "$1''{\cdot}0806$ corresponding to a velocity 1344 f. s., and $2''{\cdot}1464$ "to a velocity 1129 f. s. Hence (time required) $\times\, d^2 \div w$ "$= 2''{\cdot}1464 - 1''{\cdot}0806 = 1''{\cdot}0658$, which gives the required time "$= 1''{\cdot}0658 \div {\cdot}1896 = 5''{\cdot}621$."

111. My mathematical Treatise On the Motion of Projectiles under the Action of Gravity and the Resistance of the Air, published in 1873, contained General Tables of values of $(d^2 \div w)\, s$ and $(d^2 \div w)\, t$, connecting velocity and space, and velocity and time, which were recalculated for both spherical and ogival-headed projectiles. The Tables for spherical projectiles extended from velocity 500 to 1900 f. s. (Tables X. and XI.), and those for ogival-headed projectiles from 540 to 1700 f. s. (Tables VIII. and IX.). These four Tables were reprinted in the Government Treatise on the Construction of Ordnance[1], 1877. The two Tables for ogival-headed shot were reprinted in the Proceedings of the R.A. Institution[2], 1878; also in the R.A. Handbook for Field Service[3], 1878; and in Major Sladen's Principles of Gunnery[4], 1879.

112. Professor Niven communicated a paper to the Royal Society[5] in 1877 on the approximate calculation of Trajectories of Projectiles, in which he made use of my two General Tables

$$\frac{d^2}{w}\, s, \text{ and } \frac{d^2}{w}\, t,$$

or S_v and T_v as he named them, for space and time, and gave a third Table D_v of his own.

113. The experiments of 1878, 9 extended the coefficients of resistance to ogival-headed projectiles to all velocities between 400 and 2500 f. s. New General Tables for S_v and T_v were calculated by the help of these coefficients, and for the above men-

[1] pp. 359—366. [2] x. pp. 250—253. [3] pp. 292—301.
[4] pp. 55—58. [5] Proceedings, No. 181.

tioned limits of velocity which were printed as an Appendix to the Report on those experiments made with my Chronograph[1]. Immediately afterwards these two Tables were reprinted in the Manual of Gunnery for H.M. Fleet, 1880; and also in an abridged form in the article "Gunnery" in the new edition of the Encyclopædia Britannica, 1880.

114. Lastly, the coefficients given in the Final Report of 1880, enabled me to extend my General Tables for ogival-headed projectiles to all velocities between 100 and 2800 f. s. These General Tables were first printed as an Appendix to the "Final Report," 1880. They were subsequently reprinted in the Manual of Gunnery for H.M. Fleet, 1880; also in the Text Book of Gunnery by Major Mackinlay, R.A., 1883 and 1887; and in the Treatise on Small Arms by Colonel Bond, R.A., 1884 and 1888.

115. Although my coefficients of resistance were derived from experiments made with guns of 3 to 9-inch calibre, Major McClintock, R.A., has found by careful experiment that they hold good for small-arm bullets, for he remarks "The accuracy of rifle-"bullet trajectories calculated by means of Professor Bashforth's "Tables has been tested by firing a large number of rounds through "paper screens placed at different points along the range....The "screens were erected at intervals along a 500 yards and a "1000 yards range. The result of the experiments was most "satisfactory, the mean heights of the bullet-holes in the screens "agreeing closely with the heights found by calculation[2]."

[1] Report, &c. Part II. 1879, pp. 51—58.

[2] Proceedings of the R. A. Inst. XII. p. 569.

CHAPTER V.

CALCULATION OF TRAJECTORIES OF PROJECTILES.

116. THE following is an explanation of the principal symbols used—g denotes the accelerating force of gravity and equals 32·191 f. s. in the Latitude of Greenwich. g (French measure) $= 9{\cdot}809$ m. s., w the weight of the shot in pounds, p the weight in kilogrammes, d the diameter of the shot in inches, a the diameter in centimetres. f the retarding effect of the air for a velocity of v feet per second $= -2bv^3$ when supposed to vary as the *cube* of the velocity; or $= -2cv^2$ when supposed to vary as the *square* of the velocity; or $= -2ev^n$ when supposed to vary as the n^{th} power of the velocity of the projectile.

$$K = 2b\frac{w}{d^2}(1000)^3;\ \ k = 2c\frac{w}{d^2}(1000)^2;\ \ k = K\frac{v}{1000}.$$

x, y are the horizontal and vertical coordinates of the centre of gravity of the projectile, at the time t, when the shot has described an arc s. ϕ is the inclination to the horizon of the tangent to the trajectory at the point x, y. v_ϕ denotes the velocity of the shot in the ascending branch of the trajectory, when moving in a direction inclined to the horizon at an angle ϕ, and u_ϕ is corresponding horizontal velocity so that $u_\phi = v_\phi \cos\phi$. v_ϕ' and u_ϕ' denote similar quantities in the descending branch of the trajectory. ω denotes the weight of a cubic foot of air in grains. Π denotes the weight of a cubic metre of air in kilogrammes. When ogival-headed shot are mentioned in this treatise without any further particulars, it may be assumed that the heads are struck with a radius of one diameter and a half, which was the form used in the chief experiments. Elongated projectiles are all supposed to have a right-hand rotation about their own axes.

117. Suppose a projectile to be fired in a direction inclined at an angle α above the horizontal plane through the muzzle, to be acted upon by gravity g in parallel lines, and by a retarding force $2e\,(\text{velocity})^n$ acting at every point in the direction of the tangent to the trajectory of the projectile at that point which is assumed to pass through the centre of gravity of the shot, then there will be no force tending to draw the projectile out of the vertical plane of projection. Let the point of projection be taken for the origin, and let the axes of coordinates x and y be respectively horizontal and vertical, and in the vertical plane of projection. Let x, y be the coordinates of the centre of gravity of the shot at the time t, when the shot has described an arc s of its trajectory.

The equations of motion are

$$\frac{d^2x}{dt^2} = -2e\left(\frac{ds}{dt}\right)^n \frac{dx}{ds} = -2e\left(\frac{ds}{dt}\right)^{n-1} \frac{dx}{dt},$$

and

$$\frac{d^2y}{dt^2} = -2e\left(\frac{ds}{dt}\right)^n \frac{dy}{ds} - g = -2e\left(\frac{ds}{dt}\right)^{n-1} \frac{dy}{dt} - g,$$

therefore

$$\frac{dx}{dt}\frac{d^2y}{dt^2} - \frac{dy}{dt}\frac{d^2x}{dt^2} = -g\frac{dx}{dt}.$$

As usual suppose

$$p = \frac{dy}{dx},$$

then

$$\frac{dp}{dt} = \frac{\dfrac{dx}{dt}\dfrac{d^2y}{dt^2} - \dfrac{d^2x}{dt^2}\dfrac{dy}{dt}}{\left(\dfrac{dx}{dt}\right)^2} = -\frac{g}{\dfrac{dx}{dt}},$$

or

$$\frac{dp}{dt}\frac{dx}{dt} = -g, \text{ and also } \frac{dp}{dx}\left(\frac{dx}{dt}\right)^2 = -g,$$

or

$$\frac{dt}{dp} = -\frac{u}{g}; \text{ and } \frac{dx}{dp} = -\frac{u^2}{g} \quad\text{.....................(1).}$$

118. Again

$$\frac{d^2x}{dt^2} = -2e\left(\frac{ds}{dt}\right)^n \frac{dx}{ds} = -2e\left(\frac{ds}{dx}\right)^{n-1}\left(\frac{dx}{dt}\right)^n,$$

or

$$\frac{du}{dt} = -2e\,(1+p^2)^{\frac{n-1}{2}}\,u^n.$$

Therefore

$$\frac{1}{u^{n+1}}\frac{du}{dt} = -2e\,(1+p^2)^{\frac{n-1}{2}}\frac{1}{u} = \frac{2e}{g}(1+p^2)^{\frac{n-1}{2}}\frac{dp}{dt} \text{ by (1).}$$

Integrating $$-\frac{1}{nu^n} = C + \frac{2e}{g}\int(1+p^2)^{\frac{n-1}{2}}\,dp.$$

At the vertex, let $u = u_0$.

Then we have

$$\frac{1}{u^n} = \frac{1}{u_0^n} - \frac{2e}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp \quad\text{.................(2);}$$

$$= \frac{1}{u_0^n}\left\{1 - \frac{2eu_0^n}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp\right\},$$

therefore

$$v = u\sec\phi = \frac{u_0\sec\phi}{\left\{1 - \frac{2eu_0^n}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp\right\}^{\frac{1}{n}}} \quad\text{................(3).}$$

From (1) we have

$$\frac{dt}{dp} = -\frac{u}{g} = -\frac{u_0}{g}\cdot\frac{1}{\left\{1 - \frac{2eu_0^n}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp\right\}^{\frac{1}{n}}} \quad\text{................(4).}$$

Now $$\frac{2eu_0^n}{g} = \frac{M\times 2eu_0^n}{Mg}$$

$$= \frac{\text{Resistance of the air at the vertex to the shot}}{\text{weight of the shot}} \quad\text{...(5);}$$

$$\therefore\quad t = -\frac{u_0}{g}\int_{\phi}^{\phi'}\frac{(1+p^2)\,d\phi}{\left\{1 - \frac{2eu_0^n}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp\right\}^{\frac{1}{n}}} \quad\text{..... ....(6),}$$

since $$dp = d\tan\phi = \sec^2\phi\,d\phi = (1+p^2)\,d\phi.$$

Again by (1) we have

$$\frac{dx}{dp} = -\frac{u^2}{g} = -\frac{u_0^2}{g}\,\frac{1}{\left\{1 - \frac{2eu_0^n}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp\right\}^{\frac{2}{n}}},$$

or $$x = -\frac{u_0^2}{g}\int_{\phi}^{\phi'}\frac{(1+p^2)\,d\phi}{\left\{1 - \frac{2eu_0^n}{g}\,n\int(1+p^2)^{\frac{n-1}{2}}\,dp\right\}^{\frac{2}{n}}} \quad\text{...........(7),}$$

and since $$\frac{dy}{dx} = p,\quad \frac{dy}{dp} = p\frac{dx}{dp}.$$

Hence $$y = -\frac{u_0^2}{g}\int_{\phi}^{\phi'} \frac{(p+p^3)\,d\phi}{\left\{1 - \frac{2eu_0^n}{g}\, n\int (1+p^2)^{\frac{n-1}{2}}\, dp\right\}^{\frac{2}{n}}} \quad \text{...........(8).}$$

So also $$s = -\frac{u_0^2}{g}\int_{\phi}^{\phi'} \frac{(1+p^2)^{\frac{3}{2}}\,d\phi}{\left\{1 - \frac{2eu_0^n}{g}\, n\int (1+p^2)^{\frac{n-1}{2}}\, dp\right\}^{\frac{2}{n}}} \quad \text{...........(9).}$$

119. Suppose that the retarding force varies as the *square* of the velocity, then

$$n = 2\,;\quad 2e = 2c = k\frac{d^2}{w}\frac{1}{(1000)^2}\,;$$

and by (5) $$\frac{2eu_0^n}{g} = \frac{2cu_0^2}{g} = \frac{k}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^2 = \lambda \text{ suppose.........(10),}$$

also $$n\int (1+p^2)^{\frac{n-1}{2}}\,dp = 2\int (1+p^2)^{\frac{1}{2}}\,dp$$

$$= \tan\phi\sec\phi + \log_e \tan\left(\frac{\pi}{4}+\frac{\phi}{2}\right) = Q_\phi \text{ (see Table VII.),}$$

and by (2) $$\left(\frac{1000}{u}\right)^2 = \left(\frac{1000}{u_0}\right)^2 - \frac{k}{g}\frac{d^2}{w}Q_\phi \text{..............(11).}$$

Therefore

by (3) $$\frac{v}{u_0} = \frac{\sec\phi}{\{1-\lambda Q_\phi\}^{\frac{1}{2}}} = \frac{1}{10^3}(v) \text{....................(12),}$$

by (6) $$t = -\frac{u_0}{g}\int_{\phi}^{\phi'} \frac{(1+p^2)\,d\phi}{\{1-\lambda Q_\phi\}^{\frac{1}{2}}} = -\frac{u_0}{10^4 g}\,({}^{\phi}t_\lambda{}^{\phi'}) \text{.........(13),}$$

by (7) $$x = -\frac{u_0^2}{g}\int_{\phi}^{\phi'} \frac{(1+p^2)\,d\phi}{\{1-\lambda Q_\phi\}} = -\frac{u_0^2}{10^4 g}\,({}^{\phi}x_\lambda{}^{\phi'}) \text{.........(14),}$$

by (8) $$y = -\frac{u_0^2}{g}\int_{\phi}^{\phi'} \frac{(p+p^3)\,d\phi}{\{1-\lambda Q_\phi\}} = -\frac{u_0^2}{10^4 g}\,({}^{\phi}y_\lambda{}^{\phi'}) \text{.. ......(15),}$$

by (9) $$s = -\frac{u_0^2}{g}\int_{\phi}^{\phi'} \frac{(1+p^2)^{\frac{3}{2}}\,d\phi}{\{1-\lambda Q_\phi\}}$$

$$= -\frac{u_0^2}{g}\int_{p}^{p'} \frac{(1+p^2)^{\frac{1}{2}}\,dp}{\{1-\lambda Q_\phi\}}$$

$$= \frac{u_0^2}{2\lambda g}\int_{\phi}^{\phi'} \frac{d\{1-\lambda Q_\phi\}}{\{1-\lambda Q_\phi\}} = \frac{u_0^2}{2\lambda g}\log_e\left\{\frac{1-\lambda Q_{\phi'}}{1-\lambda Q_\phi}\right\} \text{......(16).}$$

Here s the length of the arc of the trajectory is the only quantity that can be found by integration. The values of (t), (x) and (y) calculated by quadratures and also of (v), for useful values of λ and ϕ, will be found in Table IX.

120. Suppose next that the retarding force varies as the *cube* of the velocity, then

$$n = 3\,;\ 2e = 2b = K\frac{d^2}{w}\left(\frac{1}{1000}\right)^3,$$

and by (5) $$\frac{2eu_0^n}{g} = \frac{2bu_0^3}{g} = \frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = \gamma \text{ suppose (17)},$$

also $$n\int (1+p^2)^{\frac{n-1}{2}} dp = 3\int (1+p^2)\,dp$$

$$= 3\tan\phi + \tan^3\phi = P_\phi \text{ (see Table XV.)}.$$

By (2) $$\left(\frac{1000}{u}\right)^3 = \left(\frac{1000}{u_0}\right)^3 - \frac{K}{g}\frac{d^2}{w}P_\phi \ldots\ldots\ldots\ldots\ldots(18),$$

by (3) $$\frac{v}{u_0} = \frac{\sec\phi}{\{1-\gamma P_\phi\}^{\frac{1}{3}}} = \frac{1}{10^3}(\text{V}) \ldots\ldots\ \ldots\ldots\ldots(19),$$

by (6) $$t = -\frac{u_0}{g}\int_\phi^{\phi'} \frac{(1+p^2)\,d\phi}{\{1-\gamma P_\phi\}^{\frac{1}{3}}} = -\frac{u_0}{10^4 g}({}^{\phi}\text{T}_\gamma{}^{\phi'}) \ldots\ldots(20),$$

by (7) $$x = -\frac{u_0^2}{g}\int_\phi^{\phi'} \frac{(1+p^2)\,d\phi}{\{1-\gamma P_\phi\}^{\frac{2}{3}}} = -\frac{u_0^2}{10^4 g}({}^{\phi}\text{X}_\gamma{}^{\phi'}) \ldots\ldots(21),$$

by (8) $$y = -\frac{u_0^2}{g}\int_\phi^{\phi'} \frac{(p+p^3)\,d\phi}{\{1-\gamma P_\phi\}^{\frac{2}{3}}} = -\frac{u_0^2}{10^4 g}({}^{\phi}\text{Y}_\gamma{}^{\phi'}) \ldots\ldots(22);$$

(X), (Y) and (T) have been calculated by quadratures for useful values of γ and ϕ. These results and corresponding values of (V) will be found in Table XVI. Intermediate values of these quantities must be found by proportional parts or, where greater accuracy is required, by interpolation.

121. Lastly, suppose that the retarding force arising from the resistance of the air varies as the 6th power of the velocity, then

$$n = 6,$$

and $$n\int(1+p^2)^{\frac{n-1}{2}}\,dp = 6\int(1+p^2)^{\frac{5}{2}}\,dp$$

$$= \tan\phi\left\{\sec^5\phi + \frac{5}{4}\sec^3\phi + \frac{15}{8}\sec\phi\right\} + \frac{15}{8}\log_e\tan\left(\frac{\pi}{4}+\frac{\phi}{2}\right)$$

$$= W_\phi \text{ (see Table XVIII.)} \quad\ldots\ldots\ldots\ldots(23),$$

and by (2) $$\left(\frac{1000}{u}\right)^6 = \left(\frac{1000}{u_0}\right)^6 - \frac{2e'}{g}(1000)^6 W_\phi$$

$$= \left(\frac{1000}{u_0}\right)^6 - \frac{L}{g}\frac{d^2}{w} W_\phi \quad\ldots\ldots\ldots\ldots(24).$$

Tables for calculating the values of x, y and t have not been prepared for this case. Hence it will be necessary to use those prepared for the cubic or Newtonian Law or the General Tables after the velocity has been calculated.

Professor Greenhill has published some elaborate papers on the Motion of a Projectile in a resisting medium[1]. He also effects a complete solution when the resistance is supposed to vary as the cube of the velocity[2]. Professor Greenhill has also published papers on the Rotation required for the stability of an elongated projectile[3], and on "Drift[4]."

Examples of the Calculation of Trajectories.

122. We now proceed to give various examples of the use of this treatise in calculating trajectories of projectiles.

For the purpose of testing my coefficients we will make use of Range Tables, which have been carefully derived from actual experiment and where the muzzle velocity and "jump" have been measured. One of these Range Tables is that for the 6·3-inch Howitzer where the muzzle velocity is 751 f. s. These Range Tables were originally sent to me to show that my coefficients of 1879 did not give satisfactory results when tested by them. Certainly my *general* Tables could not be expected to apply to trajectories *so much curved*. But when the trajectory was broken up into short arcs and so properly calculated, the results agreed

[1] Proceedings of the R. A. Inst. xi. pp. 113, 589; xii. p. 17.
[2] Ib. xiv. p. 373. [3] Ib. x. p. 589. [4] Ib. xi. p. 124.

extremely well with the Range Tables[1]. For examples of heavy shot I have used the Range Table recently prepared with great care by Captain H. J. May, R.N., for 12-inch shot fired at elevations of 0° to 4°.[2] Further, I have used the Range Table of the 4-inch B.L. gun, in order to secure great variation of velocity. After the publication of Krupp's Tables this was the gun selected by Government in 1887 to be used in testing my coefficients of Resistance (K) on a *long* range, when they were found to be quite satisfactory, although originally obtained from experiments on *short* ranges.

6·3-inch Howitzer. Ranges calculated on a horizontal plane 6·5 feet below the muzzle, $d = 6{\cdot}27$ inches, $w = 70$ lbs., no allowance for "jump." Angles of departure 5°, 10°, 15°, 20°, 25°, 30° and 35°.

Muzzle velocity 751 f. s. Range Table derived from instructions for the service of field guns, 1879.

(1) $\alpha = 5°$, $V \cos 5° = 748{\cdot}1$.

By (11) we have $\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{748{\cdot}1}\right)^2 + \frac{k}{g}\frac{d^2}{w} Q_5$.

$$\log \frac{k}{g} = 0{\cdot}27402 \quad \text{Table IV.}$$

$$\log \frac{d^2}{w} = 9{\cdot}74944$$

$$\log \frac{k}{g}\frac{d^2}{w} = 0{\cdot}02346$$

$$\log Q_5 = 9{\cdot}24353$$

$$9{\cdot}26699$$

therefore $$\frac{k}{g}\frac{d^2}{w} Q_5 = 0{\cdot}1849$$

and $$\left(\frac{1000}{u_0}\right)^2 = 1{\cdot}7868 + 0{\cdot}1849 = 1{\cdot}9717.$$

By Table X. $$u_0 = 712{\cdot}16 \text{ f. s.}$$

By (10) $$\lambda = \frac{k}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^2 = 0{\cdot}5353.$$

[1] Final Report, p. 45.

[2] Proceedings of the R. A. Inst. XIV. p. 356.

Now $\log \dfrac{1}{g} = 8{\cdot}49227$

and $\log u_0 = 2{\cdot}85258$

therefore $\log \dfrac{u_0}{g} = 1{\cdot}34485$

and $\log \dfrac{u_0^2}{g} = 4{\cdot}19743$

From Table IX., we obtain

ϕ	λ		(x)		(y)		(t)		(v)	
$+5^\circ$	0·5·	+·1	916	+8	40·7	+·5	895	+4	1051	+10
,,	0·6		924		41·2		899		1061	
,,	+ ·0353		+3		+ ·2		+1		+ 3·5	
,,	0·5353		919		40·9		896		1054·5	

$_5x_0 = 919 \times \dfrac{u_0^2}{10^4 g}$; $_5y_0 = 40{\cdot}9 \times \dfrac{u_0^2}{10^4 g}$; $_5t_0 = 896 \times \dfrac{u_0}{10^4 g}$; $v_5 = 751{\cdot}0$ f.s.

$= 1448$ feet; $= 64{\cdot}4$ feet; $= 1''{\cdot}982$.

We have to limit the descending branch by the consideration that the shot has to fall 6·5 feet more than it rose. Or the value of (y') for the descending branch must be as before 40·9, increased by

$$10^4 \times 6{\cdot}5 \div \frac{u_0^2}{g} = 4{\cdot}13,$$

or the value of (y') for the descending branch must be

$$40{\cdot}9 + 4{\cdot}1 = 45{\cdot}0.$$

On referring to Table IX. for $\lambda = 0{\cdot}5$ and $\lambda = 0{\cdot}6$ it will be found that $(y') = 45{\cdot}0$ for some value of ϕ between -5° and -6°. Hence we must calculate the values of (x'), (y'), (t') and (v') for -5° and -6° for $\lambda = 0{\cdot}5353$; and then by proportional parts we can find the value of ϕ, (x'), (t') and (v') corresponding to

$$(y') = 45{\cdot}0,$$

λ	ϕ'		(x')		(y')		(t')		(v')	
0·5353	-5°	-1	+836	+160	−36·1	−15·3	+ 856	+167	+960	−7
,,	-6°		+996		−51·4		+1023		+953	
,,	$+0^\circ{\cdot}42$		− 67		+ 6·4		− 70		+ 3	
,,	$-5^\circ{\cdot}58$		+929		−45·0		+ 953		+956	

gives

${}_0x_{5\cdot58}$ =1464 feet; ${}_0y_{5\cdot58} = -70\cdot9$ feet; ${}_0t_{5\cdot58} = 2''\cdot108$; $v'_{5\cdot58} = 680\cdot8$ f.s.
But

${}_5x_0$ =1448 „ ${}_5y_0 = +64\cdot4$ „ ${}_5t_0 = 1''\cdot982$

therefore

${}_5X_{5\cdot58} = 971$ yards; ${}_5Y_{5\cdot58} = -6\cdot5$ „ ${}_5T_{5\cdot58} = 4''\cdot09$

By Range Table

$X = 978$ yards; $Y = -6\cdot5$ „ $T = 4''\cdot29$

difference

-7 yards 0 $-0''\cdot20$

(2) $\alpha = 10^\circ$; $\left(\frac{1000}{u_0}\right)^2 = 1\cdot8281 + 0\cdot3742 = 2\cdot2023.$

By Table X., $u_0 = 673\cdot85$ f. s. and $\lambda = 0\cdot4793$.

For the ascending branch by Table IX.,

ϕ	λ	(x)	(y)	(t)	(v)
10°	0·4793	1932	175·6	1845	1115

which give

${}_{10}x_0 = 2725\cdot3$ feet; ${}_{10}y_0 = 247\cdot7$ feet; ${}_{10}t_0 = 3''\cdot862$; $v_{10} = 751\cdot3$ f. s.

For the descending branch

ϕ'	λ	(x')	(y')	(t')	(v')
$-11^\circ\cdot39$	0·4793	$+1841$	$-180\cdot2$	1925	933·7

which give

${}_0x_{11\cdot39} = 2596\cdot9$ ft.; ${}_0y_{11\cdot39} = -254\cdot2$ ft.; ${}_0t_{11\cdot39} = 4''\cdot030$; $v'_{11\cdot39} = 629\cdot2$ f.s.
But

${}_{10}x_0 = 2725\cdot3$ ft.; ${}_{10}y_0 = 247\cdot7$ ft.; ${}_{10}t_0 = 3''\cdot862$
${}_{10}X_{11\cdot39} = 1774$ yards; ${}_{10}Y_{11\cdot39} = -6\cdot5$ ft.; ${}_{10}T_{11\cdot39} = 7''\cdot892$

and by Range Table

$X = 1789$ yards; $Y = -6\cdot5$ ft.; $T = 8''\cdot040$

Difference

-15 yards 0 $-0''\cdot148$

(3) $\alpha = 15^\circ$; $\left(\frac{1000}{u_0}\right)^2 = 1\cdot9004 + 0\cdot5724 = 2\cdot4728,$

and by Table X. $u_0 = 635\cdot92$ f. s.,

and hence $\lambda = 0\cdot4269$.

And by Table IX.,

ϕ	λ	(x)	(y)	(t)	(v')
$+15^\circ$	0·4269	+3047	+425·9	+2855	
$-17^\circ{\cdot}69$	„	+2818	−431·1	+2995	928·5

${}_{15}X_{17\cdot69} = 2456$ yards; ${}_{15}Y_{17\cdot69} = -6{\cdot}5$ ft.; ${}_{15}T_{17\cdot69} = 11''{\cdot}557$; $v'_{17\cdot69} = 590$ f.s.

and by Range Table

$X = 2467$ yards; $Y = -6{\cdot}5$ ft.; $T = 11''{\cdot}700$

Difference

-11 yards $\quad 0$ „ $\quad -0''{\cdot}143$

(4) $\alpha = 20^\circ$; $\left(\frac{1000}{u_0}\right)^2 = 2{\cdot}0077 + 0{\cdot}7850 = 2{\cdot}7927.$

Hence $u_0 = 598{\cdot}39$ f. s.,

and $\lambda = 0{\cdot}378.$

ϕ	λ	(x)	(y)	(t)	(v')
20°	0·378	4268	819·4	3937	
$-24^\circ{\cdot}2$	„	3863	−825·2	4164	943

${}_{20}X_{24\cdot2} = 3015$ yards; ${}_{20}Y_{24\cdot2} = -6{\cdot}5$ ft.; ${}_{20}T_{24\cdot2} = 15''{\cdot}06$; $v'_{24\cdot2} = 564$ f. s.

and by Range Table

$X = 3000$ yards; $Y = -6{\cdot}5$ ft.; $T = 15''{\cdot}20$

Difference

$+15$ yards $\quad 0 \quad -0''{\cdot}14$

(5) $\alpha = 25^\circ$; $\left(\frac{1000}{u_0}\right)^2 = 2{\cdot}1585 + 1{\cdot}0190 = 3{\cdot}1775.$

Hence $u_0 = 561{\cdot}0$ f. s. and $\lambda = 0{\cdot}332.$

ϕ	λ	(x)	(y)	(t)	(v')
25°	0·332	5613	1392·9	5106	
$-30^\circ{\cdot}73$	0·332	4994	−1399·6	5443	978

${}_{25}X_{30\cdot74} = 3456$ yards; ${}_{25}Y_{30\cdot74} = -6{\cdot}5$ ft.; ${}_{25}T_{30\cdot74} = 18''{\cdot}383$; $v'_{30\cdot74} = 549$ f. s.

By Range Table

$X = 3467$ yards; $Y = -6{\cdot}5$ ft.; $T = 18''{\cdot}530$

Difference

-11 yards $\quad 0 \quad -0''{\cdot}147$

(6) $\alpha = 30°$; $\left(\frac{1000}{u_0}\right)^2 = 2{\cdot}3641 + 1{\cdot}2834 = 3{\cdot}6475.$

Hence $u_0 = 523{\cdot}6$ f. s.; and $\lambda = 0{\cdot}2894$.

ϕ	λ	(x)	(y)	(t)	(v')
30°	0·2894	7083	2192·0	6381	
− 37°·05	"	6226	− 2199·6	6845	1032

therefore

${}_{30}X_{37\cdot05} = 3778$ yards; ${}_{30}Y_{37\cdot05} = -6{\cdot}5$ ft.; ${}_{30}T_{37\cdot05} = 21''{\cdot}511$; $v'_{37\cdot05} = 540{\cdot}4$ f.s.

By Range Table

$X = 3813$ yards; $Y = -6{\cdot}5$ ft.; $T = 21''{\cdot}750$

Difference

-35 yards; 0 $-0''{\cdot}239$

(7) $\alpha = 35°$; $\left(\frac{1000}{u_0}\right)^2 = 2{\cdot}6424 + 1{\cdot}5913 = 4{\cdot}2337.$

Hence $u_0 = 486{\cdot}0$ f. s.; and $\lambda = 0{\cdot}2493$.

ϕ	λ	(x)	(y)	(t)	(v')
35°	0·2493	8744	3305·8	7802	
− 43°·14	"	7607	− 3314·9	8429	1107·5

therefore

${}_{35}X_{43\cdot14} = 3999$ yards; ${}_{35}Y_{43\cdot14} = -6{\cdot}5$ ft.; ${}_{35}T_{43\cdot14} = 24''{\cdot}505$; $v'_{43\cdot14} = 538$ f.s.

By Range Table

$X = 4000$ yards; $Y = -6{\cdot}5$ ft.; $T = 24''{\cdot}90$

Difference

-1 yard; 0 $-0''{\cdot}395$

123. We will now give some examples with heavy shot and high muzzle velocities, and for comparison of results we will use the Range Table[1] of Captain H. J. May, R.N., as already stated for elevations up to 4°, the limit of the table. Here the "jump" was found to be 6 minutes. Hence the results obtained by calculation for elevations of 1°, 2°, 3° and 4° must be compared with similar results derived from the Range Table for elevations of 0° 54′, 1° 54′, 2° 54′ and 3° 54′. Here $d = 12$ inches, $w = 714$ lbs.,

[1] Proceedings of the R. A. Inst. 1886, p. 356.

and muzzle velocity = 1892 f.s. The Newtonian Law holds approximately between this velocity and 1300 f. s., where

$$\log \frac{k}{g} = 0{\cdot}64211.$$

The Range &c. are calculated for the horizontal plane passing through the muzzle of the gun.

$$(1) \quad \alpha = 1^\circ; \left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{1891{\cdot}7}\right)^2 + \frac{k}{g}\frac{d^2}{w}Q_1 \text{ by (11)}$$

$$= 0{\cdot}27945 + 0{\cdot}03088 = 0{\cdot}31033.$$

Hence $u_0 = 1795{\cdot}1$ f.s., and $\lambda = 2{\cdot}851$.

ϕ	λ	(x)	(y)	(t)	(v')
$+1^\circ$	2·851	184	1·6	179	
$-1^\circ{\cdot}05$	„	174	−1·6	178	951

${}_1X_{1{\cdot}05} = 1195$ yards; ${}_1Y_{1{\cdot}05} = 0$; ${}_1T_{1{\cdot}05} = 1''{\cdot}99$; $v'_{1{\cdot}05} = 1707{\cdot}1$ f.s.

and by Range Table

$X = 1200$ yards; $Y = 0$; $T = 2''{\cdot}01$;

Difference -5 yards $\quad 0 \quad -0''{\cdot}02$

$$(2) \quad \alpha = 2^\circ; \left(\frac{1000}{u_0}\right)^2 = 0{\cdot}27968 + 0{\cdot}06180 = 0{\cdot}34148.$$

Hence $u_0 = 1711{\cdot}28$ f.s.; and $\lambda = 2{\cdot}591$.

ϕ	λ	(x)	(y)	(t)	(v')
2°	2·591	385	7·0	367	
$-2^\circ{\cdot}25$	„	356·6	−7·0	374	912·2

${}_2X_{2{\cdot}25} = 2249$ yards; ${}_2Y_{2{\cdot}25} = 0$; ${}_2T_{2{\cdot}25} = 3''{\cdot}939$; $v'_{2{\cdot}25} = 1561{\cdot}5$ f.s.

and by Range Table

$X = 2267$ yards; $Y = 0$; $T = 3''{\cdot}977$

Difference -18 yards $\quad 0 \quad -0''{\cdot}038$

$$(3) \quad \alpha = 3^\circ; \left(\frac{1000}{u_0}\right)^2 = 0{\cdot}28012 + 0{\cdot}09277 = 0{\cdot}37289.$$

Hence $u_0 = 1637{\cdot}6$ f. s.; and $\lambda = 2{\cdot}372$.

ϕ	λ	(x)	(y)	(t)	(v')
$+3^\circ$	2·372	603	16·54	561·4	
$-3^\circ{\cdot}57$	„	546·5	−16·54	584·0	880·5

${}_3X_{3{\cdot}57} = 3192$ yards; ${}_3Y_{3{\cdot}57} = 0$; ${}_3T_{3{\cdot}57} = 5''{\cdot}827$; $v'_{3{\cdot}57} = 1442$ f. s.

and by Range Table

$X = \underline{3200}$ yards; $Y = \underline{0}$; $T = \underline{5''\cdot86}$

Difference $\underline{\underline{-8}}$ yards $\underline{\underline{0}}$ $\underline{\underline{-0''\cdot033}}$

$$(4) \quad \alpha = 4°; \left(\frac{1000}{u_0}\right)^2 = 0\cdot28072 + 0\cdot12382 = 0\cdot40454.$$

Hence $u_0 = 1572\cdot2$ f. s.; and $\lambda = 2\cdot187$.

ϕ	λ	(x)	(y)	(t)	(v')
$+4°$	2·187	835	30·9	762·6	
$-5°\cdot02$	"	743	$-30\cdot9$	807·7	853·3

${}_4X_{5\cdot02} = 4039$ yards; ${}_4Y_{5\cdot02} = 0$; ${}_4T_{5\cdot02} = 7''\cdot667$; $v'_{5\cdot02} = 1341\cdot6$ f. s.

and by Range Table

$X = \underline{4057}$ yards; $Y = \underline{0}$; $T = \underline{7''\cdot742}$

Difference $\underline{\underline{-18}}$ yards $\underline{\underline{0}}$ $\underline{\underline{-0''\cdot075}}$

The calculated time of flight over

$$4057 \text{ yds.} = \text{time over } 4039 + \text{time over } 18 \text{ yards}$$
$$= 7''\cdot667 + 0''\cdot040 = 7''\cdot707$$

which is $0''\cdot035$ less than $7''\cdot742$ the time given by the Range Table.

124. Using the horizontal muzzle velocities, the following have been found to be the times of flight by the General Tables, for the distances and elevations specified for the 12-inch B. L. gun.

	Elevations	0° 54′	1° 54′	2° 54′ and	3° 54′
By Range Table	Range	1200	2267	3200	4057 yards
By Range Table	Time of Flight	2″·010	3″·977	5″·860	7″·742
Calculated Time of Flight		2″·002	3″·967	5″·845	7″·715
	Difference	−0″·008	−0″·010	−0″·015	−0″·027

125. Next we will calculate several rounds for shot fired from the 4-inch B. L. gun and compare the results with those given in the Range Table. Here $d = 4$ inches; $w = 25$ lbs.; muzzle velocity $= 1900$ f. s. The "jump" is 6 minutes. The range is calculated on

the horizontal plane passing through the muzzle, as we have no information on this point.

(1) $\alpha = 1°$; $\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{u_1}\right)^2 + \frac{k\,d^2}{g\,w} Q_1$

$$= 0·27709 + 0·09801 = 0·37510.$$

Hence $u_0 = 1632·8$ f.s. and $\lambda = 7·484 = 7·5$ nearly.

ϕ	λ	(x)	(y)	(t)	(v')
$+1°$	7·5	202	$+1·9$	188	
$-1°·184$	,,	178	$-1·9$	191·8	875·3

and ${}_1X_{1·184} = 1049$ yards; ${}_1Y_{1·184} = 0$; ${}_1T_{1·184} = 1''·927$; $v'_{1·184} = 1429$ f.s. and by the Range Table

	$X = 1083$ yards;	$Y = 0$;	$T = 1''·970$
Difference	-34 yards	0	$-0''·043$

Where the tabular values of (V) or (v) change rapidly it will be necessary to use formula (19) or (12) when precision is required.

(2) $\alpha = 2°$; $\left(\frac{1000}{u_0}\right)^2 = 0·27735 + 0·19611 = 0·47346.$

Hence $u_0 = 1453·3$ f. s. and $\lambda = 5·929$.

ϕ	λ	(x)	(y)	(t)	(v')
$+2°$	5·929	450·7	8·61	395·4	
$-2°·764$	,,	380·3	$-8·61$	427·3	799·3

and ${}_2X_{2·764} = 1817$ yards; ${}_2Y_{2·764} = 0$; ${}_2T_{2·764} = 3''·714$; $v'_{2·764} = 1162$ f. s. By Range Table

	$X = 1811$ yards;	$Y = 0$;	$T = 3''·72$
Difference	$+6$ yards	0	$-0''·006$

(3) $\alpha = 3°$; $\left(\frac{1000}{u_0}\right)^2 = 0·27777 + 0·29439 = 0·57216.$

Hence $u_0 = 1322·0$ f.s. and $\lambda = 4·906 = 4·9$ nearly.

ϕ	λ	(x)	(y)	(t)
3°	4·9	735	21·6	61·7

or ${}_3x_0 = 3991$ feet; ${}_3y_0 = 117·3$ feet; ${}_3t_0 = 2''·534$.

As the law changes from the Newtonian to the cubic at a velocity of about 1300 f.s. it will be convenient to change the law at the vertex; then

$$\gamma = \frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = 3{\cdot}3891 \times 0{\cdot}64 \times (1{\cdot}322)^3 = 5{\cdot}012 = 5{\cdot}0 \text{ nearly.}$$

ϕ	γ	(X)	(Y)	(T)	(V′)
$-4^\circ{\cdot}512$	5·0	59·4	−21·6	68·3	773·9

and

$${}_0x_{4\cdot53} = 3227{\cdot}5 \text{ feet};\quad {}_0y_{4\cdot53} = -117{\cdot}3 \text{ feet};\quad {}_0t_{4\cdot53} = 2''{\cdot}805.$$

But

$${}_3x_0 = 3991 \text{ feet};\quad {}_3y_0 = +117{\cdot}3 \text{ feet};\quad {}_3t_0 = 2''{\cdot}534$$

$${}_3X_{4\cdot53} = 2406 \text{ yards};\quad {}_3Y_{4\cdot53} = 0 \quad {}_3T_{4\cdot53} = 5''{\cdot}339;\quad v'_{4\cdot53} = 1023 \text{ f.s.}$$

By Range Table

$$X = 2400 \text{ yards};\quad Y = 0 \quad T = 5''{\cdot}340$$

$$\text{Difference} + 6 \text{ yards};\quad 0 \quad -0''{\cdot}001$$

The same example may be solved by the use of French Measures,

$$\mathfrak{b} = 1900 \text{ f. s.} = 579{\cdot}11 \text{ m. s.};$$

$$\mathfrak{u} = \mathfrak{b}\cos\phi = 578{\cdot}3 \text{ m. s.};$$

$$d = 4 \text{ in.} = 10{\cdot}16 \text{ c. m.}$$

$$\mathrm{g} = 9{\cdot}809 \text{ m. s.};\quad \mathrm{p} = 11{\cdot}34 \text{ kgs.}$$

$$\text{Log}\,\frac{\mathrm{a}^2}{\mathrm{p}} = 0{\cdot}95917;$$

$$\text{Log}\,\tau = \text{Log}\,\frac{534{\cdot}22}{527} = 0{\cdot}00591;$$

$$\text{Log}\,\frac{\mathfrak{k}}{\mathrm{g}} = 0{\cdot}51518 \text{ (Table XXIX.).}$$

$$\left(\frac{1000}{\mathfrak{u}_0}\right)^2 = \left(\frac{1000}{\mathfrak{u}_3}\right)^2 + \frac{\mathfrak{k}}{\mathrm{g}}\frac{\mathrm{a}^2}{\mathrm{p}}\tau Q_3$$

$$= 2{\cdot}9902 + 3{\cdot}1688 = 6{\cdot}1590.$$

Hence $\mathfrak{u}_0 = 402{\cdot}94$ m. s.

$$\lambda = \frac{\mathfrak{k}}{\mathrm{g}}\frac{\mathrm{a}^2}{\mathrm{p}}\tau\left(\frac{\mathfrak{u}_0}{1000}\right)^2 = 4{\cdot}906 = 4{\cdot}9 \text{ nearly.}$$

$$\text{Log}\,\frac{1}{\mathrm{g}} = 9{\cdot}00838$$

$$\text{Log}\,\mathfrak{u}_0 = 2{\cdot}60525$$

$$\text{Log}\,\frac{\mathfrak{u}_0}{\mathrm{g}} = 1{\cdot}61363$$

$$\text{Log}\,\frac{\mathfrak{u}_0^2}{\mathrm{g}} = 4{\cdot}21888$$

ϕ	λ	(x)	(y)	(t)
3°	4·9	735	21·6	617

gives $\quad {}_3x_0 = 1216{\cdot}6$ m.; ${}_3y_0 = 35{\cdot}76$ m.; ${}_3t_0 = 2''{\cdot}535$.

The law of Resistance changes to the cubic law at the vertex, and

$$\gamma = 5{\cdot}011 = 5{\cdot}0 \text{ nearly.}$$

ϕ	γ	(X)	(Y)	(T)	(V′)
−4°·51	5·0	594	−21·6	682·5	774·2

gives

${}_0x_{4\cdot51} = 983{\cdot}3$ m.; ${}_0y_{4\cdot51} = -35{\cdot}76$ m.; ${}_0t_{4\cdot51} = 2''{\cdot}804$; $v'_{4\cdot51} = 312$ m.s.

But

${}_3x_0 = 1216{\cdot}6$ m.; ${}_3y_0 = +35{\cdot}76$ m.; ${}_3t_0 = 2''{\cdot}535$

${}_3X_{4\cdot51} = 2199{\cdot}9$ m.; ${}_3Y_{4\cdot51} = 0$ ${}_3T_{4\cdot51} = 5''{\cdot}339$; $v'_{4\cdot51} = 1023{\cdot}6$ f.s.

$= 2406$ yards;

By Range Table

$X = 2400$ yards; $Y = 0$ $T = 5''{\cdot}340$

Difference

$+6$ yards; 0 $-0''{\cdot}001$

(4) $\alpha = 4°$; $\left(\dfrac{1000}{u_0}\right)^2 = 0{\cdot}27836 + 0{\cdot}39293 = 0{\cdot}67129$.

Hence $u_0 = 1220{\cdot}6$ and $\lambda = 4{\cdot}182$.

The Newtonian Law holds up to a velocity of 1300 f. s. To find the value of ϕ corresponding approximately to this velocity we have $(v) = 10^3 v \div u_0 = 1300 \div 1{\cdot}22056 = 1064$. From the table it will be found that $\phi = +1°$.

ϕ	λ	(x)	(y)	(t)	(v)
+4°	4·182	1052·0	42·1	850·5	
+1°	”	188·4	1·7	181·4	1082
		863·6	40·4	669·1	

${}_4x_1 = 3997$ ft.; ${}_4y_1 = 187{\cdot}0$ ft.; ${}_4t_1 = 2''{\cdot}537$; $v_1 = 1321$ f. s.

$$\left(\frac{1000}{u_1}\right)^2 = \left(\frac{1000}{u_0}\right)^2 - \frac{k\,d^2}{g\,w}\,Q_1 = 0{\cdot}67129 - 0{\cdot}09801 = 0{\cdot}57328.$$

Hence $u_1 = 1320{\cdot}7$ f. s.

We must now use the cubic law

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_1}\right)^3 + \frac{K}{g}\frac{d^2}{w}P_1$$

$$= 0{\cdot}4341 + 0{\cdot}1136 = 0{\cdot}5477.$$

Hence $u_0 = 1222{\cdot}3$ f. s. and $\gamma = 3{\cdot}961 = 4{\cdot}0$ nearly.

This law is to continue till the velocity is reduced to 1050 f.s. Now

$$(v) = 10^3 \times 1050 \div 1222{\cdot}3 = 859,$$

which on referring to the table for $\gamma = 4{\cdot}0$ will give $\phi = -3°$.

ϕ	γ	(X)	(Y)	(T)	(V)
+1°	4·0	188	+ 1·7	181	
−3°		442	− 10·9	481	851
		630	− 9·2	662	

$_1x_3 = 2924$ ft.; $_1y_3 = -42{\cdot}72$ ft.; $_1t_3 = 2''{\cdot}514$; $v'_3 = 1040{\cdot}1$ f. s.

The law still remains the cubic as before but with reduced coefficient of resistance. The shot has to fall

$$187{\cdot}0 - 42{\cdot}72 = 144{\cdot}28 \text{ ft. vertically.}$$

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u'_3}\right)^3 - \frac{K}{g}\frac{d^2}{w}P_3 = 0{\cdot}8890 - 0{\cdot}2303 = 0{\cdot}6587,$$

which gives $u_0 = 1149{\cdot}3$ and $\gamma = 2{\cdot}221$.

The required value of (y) is

$$10^4 \times 144{\cdot}28 \div \frac{u_0^2}{g} = 35{\cdot}16$$

ϕ	γ	(X)	(Y)	(T)
− 3°	2·221	472·6	− 11·99	497·8
			− 35·16	
			− 47·15	

	ϕ	γ	(X)	(Y)	(T)	(V′)
	− 6°	2·221	871·7	− 43·12	955·4	842·0
	− 7°	,,	992·4	− 56·88	1102·2	824·8
Hence	− 6° 29	,,	906·9	− 47·15	998·0	837·0
	− 3°		472·6	− 11·99	497·8	

$$
\begin{aligned}
{}_3x_{6\cdot29} &= 1782 \text{ ft.}; & {}_3y_{6\cdot29} &= -\ 144\cdot22 \text{ ft.}; & {}_3t_{6\cdot29} &= 1''\cdot786; & v'_{6\cdot29} &= 962 \text{ f. s.} \\
{}_1x_3 &= 2924 \text{ ft.}; & {}_1y_3 &= -\ \ 42\cdot72 \text{ ft.}; & {}_1t_3 &= 2''\cdot514 \\
{}_4x_1 &= \underline{3997} \text{ ft.}; & {}_4y_1 &= +\underline{187\cdot00} \text{ ft.}; & {}_4t_1 &= \underline{2''\cdot537} \\
{}_4X_{6\cdot29} &= \underline{8703} \text{ ft.}; & {}_4Y_{6\cdot29} &= +\ \ \underline{0\cdot06} \text{ ft.}; & {}_4T_{6\cdot29} &= 6''\cdot837 \\
&= 2901 \text{ yards}
\end{aligned}
$$

By Range Table

$$X = \underline{2917} \text{ yards}; \qquad \underline{Y=0}; \qquad T = \underline{6''\cdot93}$$

Difference

$$\underline{\underline{-\ 16 \text{ yards}}} \qquad \underline{\underline{+\ 0\cdot06 \text{ ft.}}} \qquad \underline{\underline{-\ 0''\cdot09}}$$

$$\left(\frac{1000}{u'_{6\cdot29}}\right)^3 = 0\cdot6587 + 0\cdot4858 = 1\cdot1445$$

gives $\qquad u'_{6\cdot29} = 956\cdot0 \text{ f. s.} = 318\cdot7 \text{ y. s.}$

(5) $\alpha = 5^\circ$; $\left(\frac{1000}{u_0}\right)^2 = 0\cdot27915 + 0\cdot49184 = 0\cdot77099.$

Hence $\qquad u_0 = 1138\cdot88$ f. s. and $\lambda = 3\cdot641$.

To find where this law must be discontinued, we have

$$(v) = 10^3\, v_\phi \div u_0 = 1300 \div 1\cdot13888 = 1140,$$

which gives $\phi = +\ 2^\circ$ nearly.

ϕ	λ	(x)	(y)	(t)	(v)
$+\ 5^\circ$	3·641	1394	71·10	1092·4	
$+\ 2^\circ$	"	403	7·37	374·7	1158·7
		991	63·73	717·7	

$${}_5x_2 = 3993 \text{ ft.}; \quad {}_5y_2 = 256\cdot8 \text{ ft.}; \quad {}_5t_2 = 2''\cdot539; \quad v_2 = 1320 \text{ f. s.}$$

$$\left(\frac{1000}{u_2}\right)^2 = \left(\frac{1000}{u_0}\right)^2 - \frac{k}{g}\frac{d^2}{w}Q_2 = 0\cdot77099 - 0\cdot19611 = 0\cdot57488.$$

Hence $\qquad u_2 = 1319\cdot0$ f. s.

Here we change to the cubic law.

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_2}\right)^3 + \frac{K}{g}\frac{d^2}{w}P_2 \text{ by equation (18)}$$

$$= 0\cdot4358 + 0\cdot2273 = 0\cdot6631 \text{ by Table XVII.}$$

Hence $u_0 = 1146{\cdot}8$ f. s., and $\gamma = 3{\cdot}271$ by equation (17).

ϕ	γ	(X)	(Y)	(T)	
2°	3·271	399	7·3	373	by Table XVI.

which give

$$ {}_2x_0 = 1632{\cdot}0 \text{ feet}; \quad {}_2y_0 = 29{\cdot}8 \text{ feet}; \quad {}_2t_0 = 1''{\cdot}329 $$

But $$ {}_5x_2 = \underline{3993{\cdot}0} \;\;,, \;; \quad {}_5y_2 = \underline{256{\cdot}8} \;\;,, \;; \quad {}_5t_2 = \underline{2''{\cdot}539} $$

Therefore

$$ {}_5x_0 = 5625{\cdot}0 \;\;,, \;; \quad {}_5y_0 = 286{\cdot}6 \;\;,, \;; \quad {}_5t_0 = 3''{\cdot}868. $$

The cubic law ends when

$$ (\text{v}) = 10^3 v_\phi \div u_0 = 1100 \div 1{\cdot}147 = 959, \text{ which gives } \phi = -1°. $$

	ϕ	γ	(X)	(Y)	(T)	(V)
and	−1°	3·271	165·6	−1·4	170	950

give

$$ {}_0x_1 = 676{\cdot}5 \text{ feet}; \quad {}_0y_1 = -5{\cdot}72 \text{ feet}; \quad {}_0t_1 = 0''{\cdot}605; \quad v'_1 = 1088{\cdot}1. $$

To find u'_1 more correctly, we have

$$ \left(\frac{1000}{u'_1}\right)^3 = 0{\cdot}6631 + 0{\cdot}1136 = 0{\cdot}7767. $$

Hence $$ u'_1 = 1087{\cdot}9 \text{ f. s.} $$

To find ϕ where the velocity is *approximately* 1000 f. s., we have

$$ (\text{v}') = 10^3 v_\phi \div u_0 = 1000 \div 1{\cdot}1468 = 872, $$

and the Table for $\gamma = 3{\cdot}271$ gives $\phi = -3°$.

The resistance of the air $\propto v^6$ for velocities 1100 to 1000 f. s.

$$ \left(\frac{1000}{u'_3}\right)^6 = \left(\frac{1000}{u'_1}\right)^6 + \frac{L}{g}\frac{d^2}{w}(W_3 - W_1) \text{ by equation (24)} $$

$$ = 0{\cdot}6031 + 0{\cdot}3221 = 0{\cdot}9252 \text{ by Table XIX.} $$

which gives $u'_3 = 1013{\cdot}0$ f. s.

As we have no Tables calculated to give the values of x, y, and t for a resistance varying as the 6th power of the velocity, we must use the Tables already calculated. We will use the Cubic Law and then we have

$$\frac{K}{g}\frac{d^2}{w}(P_3 - P_1) = \left(\frac{1000}{u'_3}\right)^3 - \left(\frac{1000}{u'_1}\right)^3 = \left(\frac{1000}{1013 \cdot 0}\right)^3 - \left(\frac{1000}{1087 \cdot 9}\right)^3,$$

which gives
$$\frac{K}{g}\frac{d^2}{w} = \frac{1854}{1050}.$$

Therefore $u_0 = 1134 \cdot 9$ and $\gamma = 2 \cdot 581$.

ϕ	γ	(X)	(Y)	(T)	(V′)
$-1°$	2·581	167	− 1·4	171	
$-3°$	,,	466	− 11·7	494	894

give

$_1x_3 = 1196 \cdot 4$ ft.; $_1y_3 = -41 \cdot 21$ ft.; $_1t_3 = 1'' \cdot 139$; $v'_3 = 1014 \cdot 6$ f. s.

The cubic law with a reduced coefficient holds now to the end of the range

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u'_3}\right)^3 - \frac{K}{g}\frac{d^2}{w}P_3 = 0 \cdot 9620 - 0 \cdot 2303 = 0 \cdot 7317.$$

This gives $u_0 = 1109 \cdot 8$ f. s. and $\gamma = 2 \cdot 0$.

The shot has to fall a vertical height

$$= 286 \cdot 6 - 5 \cdot 72 - 41 \cdot 21 = 239 \cdot 67 \text{ feet},$$

and
$$10^4 \times 239 \cdot 67 \div \frac{u_0^2}{g} = 62 \cdot 66.$$

ϕ	γ	(X)	(Y)	(T)	(V)
$-3°$	2·0	477	− 12·1	500	
$-8° \cdot 04$	,,	1135	− 74·76	1264	822·4

$_8x_{8 \cdot 04} = 2517 \cdot 3$ ft.;	$_3y_{8 \cdot 04} = -239 \cdot 7$ ft.;	$_3t_{8 \cdot 04} = 2'' \cdot 634$;	$v'_{8 \cdot 04} = 912 \cdot 6$ f.s.
$_1x'_3 = 1196 \cdot 4$,,	$_1y_3 = -41 \cdot 2$ ft.;	$_1t_3 = 1'' \cdot 139$	
$_0x_1 = 676 \cdot 5$,,	$_0y_1 = -5 \cdot 7$ ft.;	$_0t_1 = 0'' \cdot 605$	
$_0x_{8 \cdot 04} = 4390 \cdot 2$,,	$_0y_{8 \cdot 04} = -286 \cdot 6$ ft.;	$_0t_{8 \cdot 04} = 4'' \cdot 378$	
$_5x_0 = 5623 \cdot 0$,,	$_5y_0 = +286 \cdot 6$ ft.;	$_5t_0 = 3'' \cdot 865$	
$_5X_{8 \cdot 04} = 3338$ yds.;	$_5Y_{8 \cdot 04} = 0$	$_5T_{8 \cdot 04}$ 8″·243	
By Range Table			
$X = 3392$ yds.;	$Y = 0$	$T = 8'' \cdot 440$	
Difference			
− 54 yards	0	− 0″·197	

In this descending branch we might have neglected to introduce the law of resistance $\propto v^6$ from $v = 1100$ to 1000 f. s. and instead of that changed the coefficient of the cubic law at the velocity 1050 f. s. We must on this supposition make the change at $\phi = -2°$.

ϕ	γ	(X)	(Y)	(T)	(V)
$-2°$	3·271	315·3	$-$ 5·36	331·6	907

gives ${}_0x_2 = 1288$ ft.; ${}_0y_2 = -21·9$ ft.; ${}_0t_2 = 1''·181$; $v'_2 = 1040·1$.

$$\left(\frac{1000}{u'_2}\right)^2 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\,\frac{d^2}{w}P_2 = 0·6631 + 0·2273 = 0·8904$$

gives $$u'_2 = 1039·5 \text{ f. s.}$$

For the remainder of the trajectory we use

$$\log\frac{K}{g} = 0·35915,$$

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u'_2}\right)^3 - \frac{K}{g}\,\frac{d^2}{w}P_2 = 0·8904 - 0·1534 = 0·7370$$

gives $u_0 = 1107·1$ f. s. and $\gamma = 1·985 = 2·0$ nearly.

The vertical height of the shot when $\phi = -2°$ is

$$286·6 - 21·9 = 264·7 \text{ feet},$$

which gives $$(\text{Y}') = 10^4 \times 264·7 \div \frac{u_0^{\,2}}{g} = 69·5.$$

ϕ	γ	(X)	(Y)	(T)	(V′)
$-2°$	$2°0$	327	$-$ 5·6	338	
$-8°·06$	,,	1137	$-$ 75·1	1267	822

give

${}_2x_{8·06} = 3084·0$ ft.; ${}_2y_{8·06} = -264·61$ ft.; ${}_2t_{8·06} = 3''·195$; $v'_{8·06} = 910·0$ f. s.

${}_0x_2 = 1288$ ft.; ${}_0y_2 = -\ 21·9$ ft.; ${}_0t_2 = 1''·181$

${}_0x_{8·06} = 4372$ ft.; ${}_0y_{8·06} = -286·5$ ft.; ${}_0t_{8·06} = 4''·376$

${}_5x_0 = 5625$ ft.; ${}_5y_0 = +286·6$ ft.; ${}_5t_0 = 3''·865$

${}_4X_{8·06} = 3332$ yards; ${}_5Y_{8·06} = +\ 0·1$ ft.; ${}_5T_{8·06} = 8''·243$

By Range Table

$X = 3392$ yards; $Y = 0·0$ ft.; $T = 8''·44$

Difference

$= -60$ yards $= +\ 0·1$ ft. $-0''·197$

126. The General Tables have also been used to calculate the times of flight over the ranges given by the Range Table for the following elevations of the 4-inch B.L. gun.

Elevation	0°. 54′	1°. 54′	2°. 54′	3°. 54′	4°. 54′
Range Table. Ranges.........	1083	1811	2400	2917	3392 yds.
,, ,, Times of Flight	1″·97	3″·72	5″·34	6″·93	8″·44
Calculated Time of Flight ...	1″·997	3″·704	5″·336	6″·909	8″·459
Difference	+0″·027	−0″·016	−0″·004	−0″·021	+0″·019

The close agreement between calculation and experiment for ranges up to near two miles affords conclusive evidence of the correctness of the coefficients of resistance adopted.

127. Taking now the 4-inch B.L. gun of 13½ cwt. fired at an elevation of 10° with a muzzle-velocity of 1180 f. s.

$$d = 4 \text{ inches}; \quad w = 25 \text{ lbs.}; \quad \text{"jump"} = 6 \text{ minutes},$$

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_{10}}\right)^3 + \frac{K}{g}\frac{d^2}{w}P_{10}$$

$$= 0{\cdot}6372 + 1{\cdot}1593 = 1{\cdot}7965.$$

Hence $u_0 = 822{\cdot}6$ f. s. and $\gamma = 1{\cdot}207$.

We will neglect the consideration of the resistance varying as v^6 between the velocities 1100 and 1000 f. s., and suppose that a sudden change takes place at 1050 f. s. at which velocity the value of $\log\frac{K}{g}$ falls from 0·53009 to 0·35915, but the cubic law holds on both above and below that velocity.

Here $10^3 v_\phi \div u_0 = 10^3 \times 1050 \div 822{\cdot}6 = 1276$,

which gives $\phi = 8°$,

ϕ	γ	(X)	(Y)	(T)	(V)
10°	1·207	2391	234·5	2043	
8°	,,	1750	132·7	1565	1283
or 10° to 8°		641	101·8	478	

$$_{10}x_8 = 1347{\cdot}4 \text{ ft.}; \quad _{10}y_8 = 214{\cdot}0 \text{ ft.}; \quad _{10}t_8 = 1''{\cdot}222; \quad v_8 = 1055{\cdot}4 \text{ f. s.}$$

$$\left(\frac{1000}{u_8}\right)^3 = 1{\cdot}7965 - 0{\cdot}9206 = 0{\cdot}8759.$$

Hence $u_8 = 1045{\cdot}16$ f. s.

We now use the value

$$\frac{K}{g} = 0{\cdot}35915,$$

$$\left(\frac{1000}{u_0}\right)^3 = 0{\cdot}8759 + 0{\cdot}6210 = 1{\cdot}4969.$$

Hence $u_0 = 874{\cdot}18$ f. s. and $\gamma = 0{\cdot}9775$.

ϕ	γ	(X)	(Y)	(T)	(V)
8°	0·9775	1662	123·7	1526	1208

${}_8x_0 = 3945{\cdot}5$ ft.; ${}_8y_0 = 293{\cdot}7$ ft.; ${}_8t_0 = 4''{\cdot}144$; $v_8 = 1056$ f.s.

But

${}_{10}x_8 = 1347{\cdot}4$ „ ${}_{10}y_8 = 214{\cdot}0$ „ ${}_{10}t_8 = 1''{\cdot}222$

therefore

${}_{10}x_0 = 5292{\cdot}9$ „ ${}_{10}y_0 = 507{\cdot}7$ „ ${}_{10}t_0 = 5''{\cdot}366$

The law changes at the velocity 820 f. s. Now

$$10^3 \times v_\phi \div u_0 = 10^3 \times 820 \div 874{\cdot}18 = 938 = (\text{Y}),$$

which gives $\phi = -4°$. We must therefore continue the same law to $-4°$.

ϕ	γ	(X)	(Y)	(T)	(V′)
− 4°	0·9775	656	− 22·45	677·5	942

therefore

${}_0x_4 = 1557{\cdot}3$ ft.; ${}_0y_4 = 53{\cdot}3$ ft.; ${}_0t_4 = 1''{\cdot}840$; $v'_4 = 823{\cdot}5$ f. s.

$$\left(\frac{1000}{u'_4}\right)^3 = 1{\cdot}4969 + 0{\cdot}3075 = 1{\cdot}8044,$$

which gives $u'_4 = 821{\cdot}42$ f. s.

We now pass to the Newtonian Law.

$$\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{u'_4}\right)^2 - \frac{k}{g}\frac{d^2}{w}Q_4$$

$$= 1{\cdot}4821 - 0{\cdot}1684 = 1{\cdot}3137.$$

Hence $u_0 = 872{\cdot}47$ f. s. and $\lambda = 0{\cdot}9156$.

ϕ	λ	(x)	(y)	(t)	(v)
− 13°·19	0·9156	1949	− 214·8	2134	858
− 4°·00	„	658	− 22·6	678	
− 4°	to − 13°·19	1291	− 192·2	1456	

$_4x_{13\cdot19} = 3052\cdot8$ ft.; $_4y_{13\cdot19} = -454\cdot5$ ft.; $_4t_{13\cdot19} = 3''\cdot946$; $v'_{13\cdot19} = 748$ f.s.
$_0x_4 = 1557\cdot3$ „ $_0y_4 = -\ 53\cdot3$ „ $_0t_4 = 1''\cdot840$

therefore

$_0x_{13\cdot19} = 4610\cdot1$ „ $_0y_{13\cdot19} = -507\cdot8$ „ $_0t_{13\cdot19} = 5''\cdot786$.

But

$_{10}x_0 = 5292\cdot9$ „ $_{10}y_0 = +507\cdot7$ „ $_{10}t_0 = 5''\cdot366$

Hence

$_{10}X_{13\cdot19} = 3301$ yards; $_{10}Y_{13\cdot19} = -\ 0\cdot1$ „ $_{10}T_{13\cdot19} = 11''\cdot152$

by Range Table

$X = 3414$ yards; $Y = 0\cdot0$; $T = 11''\cdot43$

Difference

-113 yards $-0\cdot1$ „ $-0''\cdot278$

128. We will now calculate the range, &c. of the 4-inch B.L. gun fired at an elevation of 15°, taking into account the variation in the density of the air, supposing that at the gun the readings of the barometer and thermometer were respectively 30 inches and 67° F. Referring to Table XX, we find the corresponding value of $\log\tau$ to be 9·9935. This corresponds to a height 5100 feet in Table XXI. It will be found by trial that the rise for the arc 1900 to 1300 f.s. is about 1000 feet, or the mean height would be 500 feet, which added to 5100 feet equals 5600 feet, which gives $\log\tau = 9\cdot9856$ by Table XXI. Muzzle velocity 1900 f.s. as before.

$$\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{1835\cdot2}\right)^2 + \frac{k}{g}\frac{d^2}{w}\tau Q_{15} = 0\cdot2969 + 1\cdot4726 = 1\cdot7695,$$

which gives $u_0 = 751\cdot75$ f.s. and $\lambda = 1\cdot535$.

The law of resistance changes at the velocity 1300 f.s. To find the corresponding value of ϕ we have $(v) = 1000v_\phi \div u_0 = 1730$, which gives $\phi = 12°$.

ϕ	λ	(x)	(y)	(t)	(v)
15°	1·535	5749	989·8	3798	
12°	„	3460	432·2	2680	1749

$_{15}x_{12} = 4018$ feet; $_{15}y_{12} = 978\cdot9$ feet; $_{15}t_{12} = 2''\cdot611$; $v_{12} = 1314\cdot8$.

$$\left(\frac{1000}{u_{12}}\right)^2 = \left(\frac{1000}{u_0}\right)^2 - \frac{k}{g}\frac{d^2}{w}\tau Q_{12} = 1\cdot7695 - 1\cdot1631 = 0\cdot6064,$$

which gives $u_{12} = 1284\cdot22$ f.s.

We will omit the law of resistance varying as v^6 and suppose the cubic law extends from 1300 to 1050 f.s. Using the above law we may find approximately the value of ϕ corresponding to 1050 f. s. for $(v) = 1000 \times 1050 \div 751{\cdot}75 = 1396$, which gives $\phi = 8°$. Then $({}^{12}y^{8}) = 432{\cdot}2 - 141{\cdot}5$ gives approximately ${}_{12}y_8 = 510$ feet. And $5100 + 979 + \frac{1}{2}510 = 6334$ feet gives $\log \tau = 9{\cdot}9741$ by Table XXI. From $\phi = 12°$ to $\phi = 8°$ the cubic law holds and $\log \frac{K}{g} = 0{\cdot}53009$ by Table IV. And

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_{12}}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_{12} = 0{\cdot}4722 + 1{\cdot}3227 = 1{\cdot}7949,$$

which gives $u_0 = 822{\cdot}82$ f. s. and $\gamma = 1{\cdot}139$.

ϕ	γ	(X)	(Y)	(T)	(V)
12°	1·139	3104	377·5	2548	
8°	„	1723	129·9	1553	1259

${}_{12}x_8 = 2905$ feet; ${}_{12}y_8 = 520{\cdot}8$ feet; ${}_{12}t_8 = 2''{\cdot}543$; $v_8 = 1036$ f. s.,

$$\left(\frac{1000}{u_8}\right)^3 = \left(\frac{1000}{u_0}\right)^3 - \frac{K}{g}\frac{d^2}{w}\tau P_8 = 1{\cdot}7949 - 0{\cdot}8672 = 0{\cdot}9277,$$

which gives $u_8 = 1025{\cdot}4$ f. s.

Suppose the above law to hold up to $\phi = 0$, the shot has to rise $129{\cdot}9 \times 10^{-4} \times (u_0^2 \div g) = 273$ feet. Now

$$5100 + 979 + 521 + \tfrac{1}{2}273 = 6737 \text{ feet},$$

which gives $\log \tau = 9{\cdot}9678$ approximately for next arc.

The cubic law of resistance still holds but the coefficient is reduced to $\log \frac{K}{g} = 0{\cdot}35915$.

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_8}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_8 = 0{\cdot}9277 + 0{\cdot}5766 = 1{\cdot}5043,$$

$$\therefore\ u_0 = 872{\cdot}75 \text{ f. s. and } \gamma = 0{\cdot}9032 = 0{\cdot}9 \text{ nearly.}$$

ϕ	γ	(X)	(Y)	(T)	(V)
8°	0·9	1635	121·0	1514	1186

or ${}_8x_0 = 3869$ ft.; ${}_8y_0 = 286{\cdot}3$ ft.; ${}_8t_0 = 4''{\cdot}105$, $v_8 = 1035{\cdot}1$ f. s.
${}_{12}x_8 = 2905$ ft.; ${}_{12}y_8 = 520{\cdot}8$ ft.; ${}_{12}t_8 = 2''{\cdot}543$
${}_{15}x_{12} = \underline{4018}$ ft.; ${}_{15}y_{12} = \underline{978{\cdot}9}$ ft.; ${}_{15}t_{12} = \underline{2''{\cdot}611}$
${}_{15}x_0 = \underline{10792}$ ft.; ${}_{15}y_0 = \underline{1786{\cdot}0}$ ft.; ${}_{15}t_0 = \underline{9''{\cdot}259}$

The law changes at the velocity 820 f. s. and

$$1000 \times 820 \div u_0 = 940,$$

which gives $\phi = -5^\circ$ and $(y) = 34{\cdot}8$, so that $34{\cdot}8 \div 10^4 \times u_0^2 \div g = 82{\cdot}35$ feet. So that the mean height for the next arc will approximately be $5100 + 1786 - \frac{1}{2}82 = 6845$ feet, which gives $\log \tau = 9{\cdot}9661$. This gives $\gamma = 0{\cdot}900$.

ϕ	γ	(X)	(Y)	(T)	(V)
-5°	0·9	814	$-34{\cdot}8$	844	935

$$\therefore\ {}_0x_5 = 1926 \text{ ft.},\quad {}_0y_5 = -82{\cdot}3 \text{ ft.},\quad {}_0t_5 = 2''{\cdot}288,\quad v'_5 = 816 \text{ f. s.},$$

$$\left(\frac{1000}{u'_5}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_5 = 1{\cdot}5043 + 0{\cdot}3561 = 1{\cdot}8604,$$

$$\therefore\ u'_5 = 813{\cdot}07 \text{ f. s.}$$

The law now changes to the Newtonian, where $\log \dfrac{k}{g} = 0{\cdot}27402$, and the mean height of the shot is $5100 + \frac{1}{2}(1716 - 82) = 5952$ which gives $\log \tau = 9{\cdot}9801$.

$$\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{u'_5}\right)^2 + \frac{k}{g}\frac{d^2}{w}\tau Q_5 = 1{\cdot}5126 - 0{\cdot}2013 = 1{\cdot}3113,$$

$$\therefore\ u_0 = 873{\cdot}27 \text{ f. s. and } \lambda = 0{\cdot}8762.$$

ϕ	λ	(x)	(y)	(t)	(v)
-5°	0·8762	814	$-34{\cdot}8$	844	
$-25{\cdot}77$	,,	3486	$-754{\cdot}1$	4085	811

$${}_5x_{25\cdot77} = 6330 \text{ feet};\quad {}_5y_{25\cdot77} = -1703{\cdot}9 \text{ feet};\quad {}_5t_{25\cdot77} = 8''{\cdot}792\quad v'_{25\cdot77} = 708{\cdot}2 \text{ f.s.}$$
$${}_0x_5 = 1926 \text{ feet};\quad {}_0y_5 = -82{\cdot}3 \text{ feet};\quad {}_0t_5 = 2''{\cdot}288\quad u'_{25\cdot77} = 637{\cdot}0$$

$${}_0x_{25\cdot77} = 8256 \text{ feet};\quad {}_0y_{25\cdot77} = -1786{\cdot}2 \text{ feet};\quad {}_0t_{25\cdot77} = 11''{\cdot}080$$
$${}_{15}x_0 = 10792 \text{ feet};\quad {}_{15}y_0 = +1786{\cdot}0 \text{ feet};\quad {}_{15}t_0 = 9''{\cdot}259$$

	${}_{15}X_{25\cdot77} =$ 6349 yards;	${}_{15}Y_{25\cdot77} =$ − 0·2 feet;	${}_{15}T_{25\cdot77} = 20''{\cdot}339$
By Range Table	$X =$ 6608 yards;	$Y =$ 0	$T = 21''{\cdot}340$
Difference	− 259 yards	− 0·2 feet	$-1''{\cdot}001$

129. I have calculated the preceding example according to the laws of resistance given in Table IV, from which I obtained the following results.

Ascending Branch.

$$
\begin{array}{lll}
{}_{15}x_{12} = 3982 \text{ feet}; & {}_{15}y_{12} = 970{\cdot}1 \text{ feet}; & {}_{15}t_{12} = 2''{\cdot}600 \\
{}_{12}x_{9} = 2253 \text{ feet}; & {}_{12}y_{9} = 418{\cdot}8 \text{ feet}; & {}_{12}t_{9} = 1''{\cdot}928 \\
{}_{9}x_{0} = \underline{4425} \text{ feet}; & {}_{9}y_{0} = \underline{373{\cdot}8} \text{ feet}; & {}_{9}t_{0} = \underline{4''{\cdot}660} \\
{}_{15}x_{0} = 10660 \text{ feet}; & {}_{15}y_{0} = 1762{\cdot}7 \text{ feet}; & {}_{15}t_{0} = 9''{\cdot}188
\end{array}
$$

Descending Branch.

$$
\begin{array}{lll}
{}_{0}x_{5} = 1881 \text{ feet}; & {}_{0}y_{5} = -\ 80{\cdot}2 \text{ feet}; & {}_{0}t_{5} = 2''{\cdot}263 \\
{}_{5}x_{20{\cdot}03} = \underline{6205} \text{ feet}; & {}_{5}y_{26{\cdot}03} = -\ \underline{1682{\cdot}9} \text{ feet}; & {}_{5}t_{26{\cdot}03} = \underline{8''{\cdot}768} \\
{}_{0}x_{26{\cdot}03} = 8086 \text{ feet}; & {}_{0}y_{26{\cdot}03} = -\ 1763{\cdot}1 \text{ feet}; & {}_{0}t_{20{\cdot}03} = 11''{\cdot}031 \\
{}_{15}x_{0} = \underline{10660} \text{ feet}; & {}_{15}y_{0} = +\ \underline{1762{\cdot}7} \text{ feet}; & {}_{15}t_{0} = \underline{9''{\cdot}188} \\
{}_{15}X_{26{\cdot}03} = 6249 \text{ yards}; & {}_{15}Y_{26{\cdot}03} = -\ 0{\cdot}4 \text{ feet}; & {}_{15}T_{26{\cdot}03} = 20''{\cdot}219
\end{array}
$$

By Range Table

$$
\begin{array}{lll}
X = \underline{6608} \text{ yards}; & Y = \underline{0} & T = \underline{21''{\cdot}340}
\end{array}
$$

Difference

$$
\begin{array}{lll}
\underline{\underline{-\ 359 \text{ yards}}} & \underline{\underline{-\ 0{\cdot}4 \text{ feet}}} & \underline{\underline{-\ 1''{\cdot}121}}
\end{array}
$$

I have also calculated the above example for an ogival head struck with a radius of two diameters, using $\kappa \frac{d^2}{w} = 0{\cdot}97 \frac{d^2}{w}$ instead of $\frac{d^2}{w}$ throughout, from which I obtained a range 6448 yards.

Where the coefficients of resistance, &c. are correct, the calculated times of flight and range ought to agree with experiment, when the air is still. But a wind might not affect the time of flight sensibly, and yet disturb the range considerably. See a paper by Colonel Maitland, R.A., "On the influence of the wind on the motion of projectiles[1]." My calculated angles of descent and terminal velocities have not been compared with those given in the Range Tables, because as these latter were not measured quantities they afforded no test of the accuracy of my coefficients.

[1] Proceedings of the R. A. Inst. VIII. p. 343.

The Jubilee Rounds.

130. When the "Jubilee" experiment was first spoken of a rough calculation was made by me, neglecting the variation of the density of the air, which gave a range of 16,709 yards for an elevation of 40°, and I then expressed an opinion that the actual range would probably be a mile or two more. But when it was resolved to carry out the experiment, I decided to calculate the range and time of flight by Bernoulli's method, using the values of the coefficients of resistance given in Table IV, and allowing for the variation in the density of the air. The muzzle velocity was supposed to be 2360 f. s.; the diameter of the shot 9·2 inches; its weight 380 lbs.; and the elevation 40°. *The atmosphere was supposed to be undisturbed,* and the force of gravity and the temperature of the air were assumed to be constant. This calculation was made with very great care, and to secure accuracy steps of a single degree were taken from 40° to 30°, and steps of two degrees from 30° to 18°. The range on a horizontal plane passing through the muzzle was thus found to be 19,436 yards and the time of flight 62″·15. These results were communicated to the Ordnance Committee, March 31, 1888. In the following month two rounds were fired at an elevation of 40°, and the ranges obtained were 21,048 and 21,358 yards with a "fresh favorable wind[1]." On this I expressed an opinion to the Ordnance Committee that "the calculated range falls so much below the experimental range *that there must be some error* either in the calculation or in the measurements." The nature of the error was apparent when in the following July two more rounds were fired at an elevation of 40°, which gave ranges of 20,236 and 20,210 yards, being about 1000 yards less than those obtained before. It was also found that the actual muzzle velocity was 2375 f. s. instead of 2360 f. s. which was used in the calculation. The long range obtained in April appeared to be due chiefly to the "fresh favorable wind" which had a much greater effect than was expected.

[1] Proceedings of the R. A. Inst. XVI. p. 491.

But it should be remembered that in the case of a steady wind, its velocity at a height of 16,000 feet would be at least *three times* its velocity on the surface of the earth, and that the wind would be acting upon the shot for at least sixty seconds. The wind, at the time the experiments were made, was generally favourable, but in no case unfavourable to a long range.

131. Afterwards the same data were used with muzzle velocity 2360 f.s. to calculate a complete Range Table for all elevations up to 45°; but the Range, Time of Flight, &c. were calculated for a horizontal plane 27 feet below the muzzle of the gun. *The air was supposed to be at rest.* This Range Table was communicated to the Ordnance Committee, Aug. 7, 1888; and it was published in "Nature" as follows, with the exception of some small corrections for elevations 1° to 4°.

Elevation	Range	Height of Vertex	Time of Flight	Angle of Descent	Striking Velocity	Horizontal Striking Velocity
°	Yards	Feet	Seconds	° ′	f. s.	y. s.
0	969	0	1·3	1 4	2,154	718
1	2,108	25	3·2	1 35	1,931	643
2	3,419	94	5·1	2 47	1,708	569
3	4,574	201	7·3	4 14	1,534	508
4	5,586	343	9·4	5 53	1,399	464
5	6,475	517	11·4	7 38	1,291	426
6	7,271	716	13·4	9 30	1,200	395
7	7,999	937	15·3	11 28	1,128	368
8	8,669	1,180	17·1	13 28	1,075	349
9	9,291	1,445	18·9	15 28	1,040	334
10	9,876	1,731	20·6	17 23	1,022	325
11	10,430	2,036	22·3	19 9	1,015	320
12	10,952	2,360	23·9	20 54	1,009	314
13	11,448	2,703	25·5	22 38	1,003	309
14	11,922	3,065	27·0	24 21	998	303
15	12,379	3,443	28·5	26 2	993	297
16	12,804	3,835	30·0	27 40	990	292
17	13,217	4,242	31·5	29 15	987	287
18	13,618	4,663	33·0	30 48	985	282
19	14,007	5,099	34·4	32 19	984	277
20	14,385	5,550	35·9	33 48	984	273
21	14,750	6,015	37·3	35 15	985	268
22	15,103	6,489	38·8	36 40	987	264
23	15,445	6,970	40·2	38 3	990	260
24	15,775	7,459	41·6	39 24	993	256
25	16,092	7,956	43·0	40 41	996	252
26	16,398	8,461	44·4	41 54	1,000	248
27	16,691	8,974	45·7	43 2	1,004	245
28	16,973	9,494	47·1	44 6	1,009	242
29	17,242	10,022	48·4	45 7	1,014	239
30	17,501	10,558	49·7	46 5	1,019	236
31	17,747	11,102	51·0	47 1	1,025	233
32	17,981	11,654	52·2	47 56	1,031	230
33	18,203	12,214	53·5	48 50	1,037	228
34	18,413	12,782	54·7	49 43	1,044	225
35	18,612	13,357	56·0	50 35	1,051	222
36	18,799	13,941	57·2	51 27	1,058	220
37	18,973	14,534	58·5	52 18	1,065	217
38	19,136	15,136	59·7	53 8	1,072	214
39	19,287	15,747	61·0	53 58	1,079	212
40	19,426	16,368	62·2	54 47	1,086	209
41	19,553	17,001	63·4	55 36	1,092	206
42	19,668	17,646	64·7	56 24	1,099	203
43	19,772	18,302	65·9	57 11	1,105	200
44	19,864	18,969	67·1	57 57	1,111	197
45	19,944	19,648	68·3	58 43	1,117	193

"It will be seen that the ranges go on increasing up to an "elevation of 45°, and would probably go on beyond an elevation "of 50° before reaching a maximum."—"Nature," Sept. 13, 1888, p. 468.

132. In July, 1888, two rounds were fired at an elevation of 30° which gave ranges of 17,500 and 18,344 yards, differing by 844 yards, although the wind appears to have been the same in both cases[1]. Again two rounds fired at an elevation of 35° gave ranges of 18,936 and 19,420 yards, which differ by 484 yards. Four rounds in all were fired at an elevation of 40° which gave ranges of 20,210, 20,236, 21,048 and 21,358 yards; so that the extreme difference of the ranges fired at this elevation was 1148 yards, fully justifying my suspicion of an error in range. A single round was fired at an elevation of 45° which gave a range of 21,800 yards, with a "favorable moderate" wind. This range is plainly far too great. In order to carry out experiments of this kind in a satisfactory manner it would be necessary to select a time when the atmosphere was at rest, and also to *test the state of affairs in the upper regions of the air by sending up trial balloons*[2]. Other experiments might be made to test the effect of the wind blowing both up and down the range. It is clear that no theoretical calculations could agree with the above discordant results of experiment.

133. Taking rounds fired in July, 1888[3], we have

Elevation	30°	35°	40°	45°
Ranges	17,500	19,420	20,236	21,800 yards
"	18,344	18,936	20,210	—— "
Mean Ranges	17,922	19,178	20,223	21,800
Difference of Mean Ranges	1,256	1,045	1,577 yards.	

We are tolerably certain that as the elevation of the gun approaches 45°, the range must be approaching a maximum in a still atmosphere, and therefore that the difference of ranges corre-

[1] Proceedings of the R. A. Inst. xvi. p. 491.

[2] From experiments on the velocity of the wind on the Eiffel Tower 994 feet above the ground and at the Paris Meteorological Office 66 feet above the ground, the average *velocity* on the tower was found to be 16 miles an hour and that at the Office only 5 miles an hour. *Nature*, Vol. 41, p. 67.

[3] Proceedings of the R. A. Inst. xvi. p. 491.

sponding to every increment of 5° in the elevation must be a *decreasing* quantity, and very different from the results stated above. In order to bring these results into something like order it will be necessary to apply corrections say of − 200 and − 1200 yds. respectively to the above mean ranges for elevations of 40° and 45° to allow for the effect of wind.

Elevations	30°	35°	40°	45°
Observed Mean Ranges	17,922	19,178	20,223	21,800 yds.
Corrections for Wind	0?	0?	− 200	− 1,200
	17,922	19,178	20,023	20,600
Differences of Corrected Ranges		1,256	845	577 yds.

Calculated Ranges (m.v. 2360 f.s.)	17,501	18,612	19,426	19,944
Correction for m.v.	+ 174	+ 185	+ 193	+ 198
Ranges (m.v. 2375 f.s.)	17,675	18,797	19,619	20,142
		1,122	822	523
Differences of above Ranges	247	381	404	458 yds.
or Difference per cent.	1·4	2·0	2·0	2·2

These deficiencies in the calculated ranges will be accounted for by the "jump", vertical "drift", wind, more pointed form of shot used in experiment, and perhaps a slight increase of the muzzle velocity due to increased elevation.

134. The calculation of the Range Table for the 9·2-inch wire gun up to an elevation of 45° with a muzzle velocity of 2360 f.s. was undertaken with a view to show the *exact results* given by the coefficients of resistance derived from my experiments with ogival-headed projectiles struck with a radius of 1½ diameter. Any needful allowance can afterwards be made for wind, a more pointed form of projectile, "jump", vertical "drift", &c.; but I have failed to obtain any evidence that my coefficients of resistance require to be reduced, as before explained. I much regret that the times of flight have not been published, because they are not nearly so much affected by the wind as ranges are.

All things considered I submit my calculated range table when there is no wind as a document far more instructive than the results of actual experiment made in windy weather, which was generally favourable to a long range.

135. The following is given as an example of the improved method pursued in the calculation of the Jubilee rounds, but in this case the muzzle velocity is 2375 instead of 2360 f.s., and the diameter of the shot is supposed to be 9·15 instead of 9·2 inches[1]. The elevation of the gun is 40°. Although the resistance of the air varies as the square of the velocity from 2375 to 1300 f.s., it seems desirable to divide the corresponding trajectory into two arcs at least, in order to take account of the decreasing density of the air. Suppose that at the gun the Barometer stands at 30 inches and the Thermometer at 60° F. Table XX. gives Log $\tau = 9{\cdot}9998$. This value is found corresponding to a height 4680 feet in Table XXI. We will suppose that the first arc rises to a height of 7800 feet above the gun. $w = 380$ lbs. Then

$$4680 + \tfrac{1}{2} \times 7800 = 8580 \text{ feet}$$

gives $\log \tau = 9{\cdot}9391$ by Table XXI.

and $\text{Log}\, d^2 \div w = 9{\cdot}34306;$

$$u_{40} = 2375 \cos 40° = 1819{\cdot}3 \text{ f. s.}$$

$$\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{u_{40}}\right)^2 + \frac{k}{g}\frac{d^2}{w}\,\tau Q_{40} = 0{\cdot}30212 + 1{\cdot}56092 = 1{\cdot}86304.$$

This gives $u_0 = 732{\cdot}66$ f.s.; and $\lambda = 0{\cdot}4509$.

ϕ	λ	(x)	(y)	(t)	(v)
40°	0·4509	17494	9429	11726	3258

We must now find the value of ϕ for the upper end of the arc when the shot has risen a height of 7800 feet. Here

$$\{({}^{40}y^0) - ({}^{\phi}y^0)\}\,\frac{u_0^{\,2}}{10^4 g} = 7800,$$

or

$$({}^{\phi}y^0) = 4751,$$

which gives $\phi = 35°$ nearly by the Table.

ϕ	λ	(x)	(y)	(t)	(v)
35°	0·4509	11499	4767	8857	2159

[1] Proceedings of the R. A. Inst. XVI. p. 492.

and therefore

$$_{40}x_{35} = 9996 \text{ ft.}; \quad _{40}y_{35} = 7773{\cdot}6 \text{ ft.}; \quad _{40}t_{35} = 6''{\cdot}530; \quad v_{35} = 1581{\cdot}8 \text{ f.s.};$$

$$\text{or} \quad \left(\frac{1000}{u_{35}}\right)^2 = \left(\frac{1000}{u_0}\right)^2 - \frac{k}{g}\frac{d^2}{w}\tau Q_{35} = 1{\cdot}8630 - 1{\cdot}2664 = 0{\cdot}5966;$$

$$\therefore \quad u_{35} = 1294{\cdot}7 \text{ f.s.}$$

The next arc of the trajectory must be made to terminate where the velocity is about 1300 f. s. In order to obtain an approximate value of ϕ for this point, we may use the same value of $\log \tau$ as before, then $(v_\phi) = 10^3 \times 1300 \div u_0 = 1774$ and we obtain $\phi = 30°$, and $(^{35}y^0) - (^{30}y^0) = 2063$, which gives $_{35}y_{30} = 3440$ feet. But as τ will be really less than we have supposed we may assume that $_{35}y_{30}$ will be 3540 feet. Then

$$4680 + 7774 + \tfrac{1}{2} \times 3540 = 14224 \text{ feet}$$

gives $$\log \tau = 9{\cdot}8510,$$

$$\left(\frac{1000}{u_0}\right)^2 = \left(\frac{1000}{u_{35}}\right)^2 + \frac{k}{g}\frac{d^2}{w}\tau Q_{35} = 0{\cdot}5966 + 1{\cdot}0339 = 1{\cdot}6305;$$

$$\therefore \quad u_0 = 783{\cdot}14 \text{ f.s.}; \text{ and } \lambda = 0{\cdot}4206 = 0{\cdot}42 \text{ nearly.}$$

ϕ	λ	(x)	(y)	(t)	(v)
35°	0·42	10893	4435	8646	
30°	„	8007	2583	6765	1651

$$_{35}x_{30} = 5499 \text{ ft.}; \quad _{35}y_{30} = 3528{\cdot}5 \text{ ft.}; \quad _{35}t_{30} = 4''{\cdot}576; \quad v_{30} = 1293{\cdot}0 \text{ f.s.}$$

$$\text{Also} \quad \left(\frac{1000}{u_{30}}\right)^2 = \left(\frac{1000}{u_0}\right)^2 - \frac{k}{g}\frac{d^2}{w}\tau Q_{30} = 1{\cdot}6305 - 0{\cdot}8339 = 0{\cdot}7966;$$

$$\therefore \quad u_{30} = 1120{\cdot}4 \text{ f.s.}$$

(3) The cubic law holds from velocity 1300 to 1100 f.s., but as we have no means of calculating x, y and t for the case where the resistance varies as the sixth power of the velocity, we will suppose the change in the coefficient of resistance to take place at a velocity near 1050 f.s.

$$(v_\phi) = 10^3 \times 1050 \div u_0 = 1341,$$

which gives $\phi = 22°$, supposing the last arc to be continued so far. But as the resistance will be less than we have supposed it to be, we will next take the arc 30° to 21°, then

$$\{(^{30}y^0) - (^{21}y^0)\} \times \frac{u_0^2}{g} \times 10^{-4} = 3126 \text{ feet.}$$

But as the resistance would be less than we have supposed it we may assume the rise in this arc to be a little more, say 3160 feet. Then $4680 + 7774 + 3529 + \frac{1}{2}\,3160 = 17563$ gives $\log \tau = 9{\cdot}7989$.

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_{30}}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_{30} = 0{\cdot}71105 + 0{\cdot}90442 = 1{\cdot}61547;$$

$$\therefore\ u_0 = 852{\cdot}25 \text{ f.s. and } \gamma = 0{\cdot}2909.$$

ϕ	γ	(X)	(Y)	(T)	(V)
30°	0·2909	7303	2295	6474	
21°	,,	4389	882·6	4101	1237·7

$${}_{30}x_{21} = 6575 \text{ ft.};\ {}_{30}y_{21} = 3186{\cdot}9 \text{ ft.};\ {}_{30}t_{21} = 6''{\cdot}282;\ v_{21} = 1054{\cdot}8 \text{ f.s.}$$

$$\left(\frac{1000}{u_{21}}\right)^3 = \left(\frac{1000}{u_0}\right)^3 - \frac{K}{g}\frac{d^2}{w}\tau P_{21} = 1{\cdot}61457 - 0{\cdot}56777 = 1{\cdot}04770;$$

$$\therefore\ u_{21} = 984{\cdot}6 \text{ f.s.}$$

If we produced the above arc to where $\phi = 0$ the vertex would be reached at a height $= 882{\cdot}6 \times \frac{u_0^2}{g} \div 10^4 = 1991$ feet, or as the resistance will be lower than we have supposed we may assume the height to be 2060 feet. Then

$$4680 + 7774 + 3529 + 3186 + \tfrac{1}{2} \times 2060 = 20199 \text{ feet},$$

which gives $\log \tau = 9{\cdot}7578.$

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_{21}}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_{21} = 1{\cdot}04770 + 0{\cdot}34844 = 1{\cdot}39614;$$

$$\therefore\ u_0 = 894{\cdot}72 \text{ f.s. and } \gamma = 0{\cdot}2066.$$

ϕ	γ	(X)	(Y)	(T)
21°	0·2066	4202	832·0	4015

	${}_{21}x_0 = 10450$ ft.;	${}_{21}y_0 = 2069{\cdot}0$ ft.;	${}_{21}t_0 = 11''{\cdot}160$
But	${}_{30}x_{21} = 6575$,, ;	${}_{30}y_{21} = 3186{\cdot}9$,, ;	${}_{30}t_{21} = 6\ {\cdot}282$
	${}_{35}x_{30} = 5499$,, ;	${}_{35}y_{30} = 3528{\cdot}5$,, ;	${}_{35}t_{30} = 4\ {\cdot}576$
	${}_{40}x_{35} = 9996$,, ;	${}_{40}y_{35} = 7773{\cdot}6$,, ;	${}_{40}t_{35} = 6\ {\cdot}530$
or	${}_{40}x_0 = 32520$ ft.;	${}_{40}y_0 = 16558{\cdot}0$ ft.;	${}_{40}t_0 = 28\ {\cdot}548$

Suppose the next arc to be taken from $\phi = 0$ to $-20°$.

$$({}^0\mathrm{Y}^{20})\,\frac{u_0^2}{g} \times 10^{-4} = 604{\cdot}2 \times \frac{u_0^2}{g}\,10^{-4} = 1503 \text{ feet.}$$

Then to find $\log\tau$ we have

$$4680 + 16558 - \tfrac{1}{2}1504 = 20486 \text{ feet},$$

which gives $\log\tau = 9{\cdot}7534$ by Table XXI.;

$$\therefore\ \gamma = 0{\cdot}2045;\ \text{and}\ u_0 = 894{\cdot}22 \text{ f.s. as before.}$$

ϕ	γ	(X)	(Y)	(T)	(V)
$-20°$	0·2045	3393	$-$ 603·3	3514	992·7

$${}_0x_{20} = 8438 \text{ ft.};\ {}_0y_{20} = -1500{\cdot}3 \text{ ft.};\ {}_0t_{20} = 9''{\cdot}767;\ v'_{20} = 888{\cdot}2 \text{ f.s.}$$

$$\left(\frac{1000}{u'_{20}}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_{20} = 1{\cdot}39614 + 0{\cdot}32551 = 1{\cdot}72165;$$

$$\therefore\ u'_{20} = 834{\cdot}35 \text{ f.s.}$$

Assuming that the same law holds for the next arc $-20°$ to $-40°$,

$$({}^{20}Y^{40}) \times \frac{u_0^2}{g}10^{-4} = 2252 \times \frac{u_0^2}{g}10^{-4} = 5600 \text{ feet.}$$

In order to find $\log\tau$, we have

$$4680 + 16558 - 1500 - \tfrac{1}{2}5600 = 16938,$$

which gives $\log\tau = 9{\cdot}8087$.

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u'_{20}}\right)^3 - \frac{K}{g}\frac{d^2}{w}\tau P_{20} = 1{\cdot}72165 - 0{\cdot}36971 = 1{\cdot}35194;$$

$$\therefore\ u_0 = 904{\cdot}4 \text{ f. s. and } \gamma = 0{\cdot}2399.$$

ϕ	γ	(X)	(Y)	(T)	(V)
$-40°$	0·2399	7020	$-$2767	7663	1086
$-20°$	,,	3357	$-$ 594·8	3494	

$${}_{20}x_{40} = 9307 \text{ ft.};\ {}_{20}y_{40} = -5519{\cdot}1 \text{ ft.};\ {}_{20}t_{40} = 11''{\cdot}712;\ v'_{40} = 982{\cdot}1 \text{ f.s.}$$

and $$\left(\frac{1000}{u'_{40}}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\frac{d^2}{w}\tau P_{40} = 1{\cdot}35194 + 1{\cdot}00789 = 2{\cdot}35983;$$

$$\therefore\ u'_{40} = 751{\cdot}12 \text{ f.s.}$$

The shot is now $+16558{\cdot}0 - 1500{\cdot}3 - 5519{\cdot}1 = 9538{\cdot}6$ feet above the level of the muzzle, and therefore the mean height above muzzle will be 4769 feet which must be diminished by 13 feet, because the arc we intend to calculate extends to 27 feet below the level of the muzzle. Therefore

$$4769 - 13 + 4680 = 9436 \text{ feet},$$

which gives $\log\tau = 9{\cdot}9257$.

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u'_{40}}\right)^3 - \frac{K}{g}\frac{d^2}{w}\tau P_{40} = 2{\cdot}3598 - 1{\cdot}3195 = 1{\cdot}0403;$$

$$\therefore\ u_0 = 986{\cdot}9 \text{ f. s. and } \gamma = 0{\cdot}4081.$$

ϕ	γ	(X)	(Y)	(T)
$-40°$	0·4081	6391	−2442	7300

The shot has to fall vertically 9538·6 + 27 = 9565·6 feet. And

$$9565{\cdot}6 \times 10^4 \div \frac{u_0^{\,2}}{g} = 3161,$$

which being added to 2442 the value of $({}^0\text{Y}^{40})$ gives $({}^0\text{Y}^{\phi}) = 5603$, and referring to the Table it will be found that ϕ falls between $-54°$ and $-55°$.

ϕ	γ	(X)	(Y)	(T)	(V)
$-54°$	0·4081	9039	−5337	11069	1096
$-55°$	,,	9251	−5634	11399	1105

which gives

$-54°{\cdot}9$	,,	9230	−5603	11366	1106
But $-40°{\cdot}0$	,,	6391	−2442	7300	——

${}_{40}x_{54\cdot9} = 8587$ ft.; ${}_{40}y_{54\cdot9} = -9565{\cdot}6$ ft.; ${}_{40}t_{54\cdot9} = 12''{\cdot}463$; $v'_{54\cdot9} = 1091$ f.s.

But	${}_{20}x_{40} = 9307$,,	${}_{20}y_{40} = -5519{\cdot}1$,,	${}_{20}t_{40} = 11{\cdot}713$
	${}_{0}x_{20} = 8438$,,	${}_{0}y_{20} = -1500{\cdot}3$,,	${}_{0}t_{20} = 9{\cdot}767$
	${}_{0}x_{54\cdot9} = 26332$ ft.	${}_{40}y_{54\cdot9} = -16585{\cdot}0$ ft.;	${}_{40}t_{54\cdot9} = 33{\cdot}943$
And	${}_{40}x_0 = 32520$,,	${}_{40}y_0 = +16558{\cdot}0$,,	${}_{40}t_0 = 28{\cdot}548$
	${}_{40}X_{54\cdot9} = 19617$ yds.	${}_{40}Y_{54\cdot9} = -27{\cdot}0$ ft.	${}_{40}T_{54\cdot9} = 62{\cdot}491$

CHAPTER VI.

ON THE MOVEMENT OF ELONGATED PROJECTILES.

"La détermination du mouvement des projectiles oblongs, "lancés par les armes à feu rayées, est un problème tres-complexe "qui pris dans toute sa généralité, présente de grandes difficultés."

St-Robert.

136. In the preceding calculations it has been supposed that the projectile moved in the vertical plane of projection. This would be the case very nearly, if the projectile was spherical and had its centre of gravity coincident with the centre of its figure, the air being at rest. But when an elongated projectile is fired from a rifled gun, the combined action of gravity and of the resistance of the air acting upon it, causes what is called a lateral "drift." The original explanation of this drift was made to depend upon a supposed greater pressure of the air upon the elongated projectile from below than from above, so that the greater friction of the air on the underside of the rotating projectile caused it to deviate to the right or left, according to the direction of its rotation. This difference of friction above and under the projectile may have some slight effect, but it would not be sufficient to produce the amount of lateral "drift" commonly observed. Even if we adopted this explanation we should have a *vertical* drift also caused by the excess of the pressure of the air upwards on the projectile.

137. Magnus gave the true explanation of all drift in 1852, which he illustrated by experiments with the gyroscope. He says: "From these experiments, we may conclude that the "deviation of elongated projectiles is caused by the resistance of "the air seeking to elevate the apex. The elevation thereby "produced is, however, scarcely perceptible, for during rotation "the forces acting on the mass of the projectile so combine them-"selves, that the apex, instead of being elevated, is *moved side-"ways*, and indeed, towards the right when the projectile rotates "to the right. In consequence of this motion to the right, the "resistance of the air presses the projectile's centre of gravity "towards the same side, and thus *produces the deviation.* At "the same time the apex sinks, and thus it appears as if the "pressure of the air against the hinder part of the projectile was "greater than that against the fore part, whereas, in fact, this "pressure is greatest on that part of the axis which is placed "between the centre of gravity and the apex[1]."

138. St-Robert published a mathematical treatise on the motion of elongated projectiles[2], in which he confirmed the explanation of drift given by Magnus. He expressed the result of his investigations in the following words: "Tandis que le "centre de gravité du projectile parcourt la trajectoire, celui-ci "tourne uniformément sur son axe de figure, qui reste immobile "dans son intérieur et qui tourne lentement dans l'espace autour "de la tangente à la trajectoire[3]."

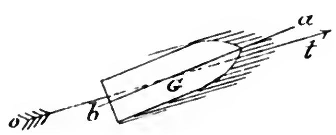
139. Mayevski also published a long paper, *De l'influence du mouvement de rotation sur la trajectoire des projectiles oblongs dans l'air*[4], in which he in a great measure followed St-Robert, and attempted to apply his results to a particular example, where the velocity of projection was low. But he was in error as he explained afterwards[5] when he supposed that the axis of the projectile made several complete revolutions about the tangent. The axis really made oscillations about the tangent whose ampli-

[1] Scientific Memoirs I. 1853, p. 228, and Abweichung der Geschosse, 1860, p. 35.
[2] Journal des Armes spéciales, 1860, and Mémoires Scientifiques, I. pp. 179—312.
[3] Ib. p. 228.
[4] Revue Technologie Militaire, 1866, pp. 1—176.
[5] Traité de Balistique, p. x.

tude did not exceed π for the *low* velocity of this projectile. Mayevski has stated the result he arrived at as follows: "Tandis "que le centre de gravité du projectile décrit une certaine trajec-"toire dans l'air, le projectile tourne autour de son axe de figure "avec une vitesse angulaire sensiblement égale à la vitesse an-"gulaire initiale, et l'axe de figure a un mouvement de rotation "autour de la tangente qui s'abaisse pendant toute la durée du "mouvement[1]." He resolves the resistance of the air as follows: "Décomposons la résultante ρ de la résistance en trois autres "résistances: l'une dirigée en sens contraire de la tangente, "l'autre perpendiculaire à la tangente dans le plan horizontal "et la troisième perpendiculaire à la tangente *dans le plan* "*vertical*." And then Mayevski explains this latter force would *raise* or *depress* the centre of gravity of the projectile according as its apex was above or below the tangent.

140. Suppose that at any instant the plane of the paper passes through the axis of the projectile *ba*, and the tangent to the trajectory *ot* at the point *G*, drawn in the direction of the

Fig. 10.

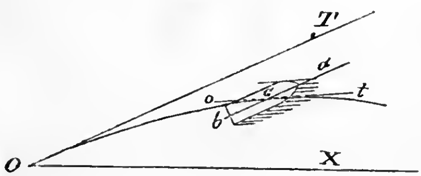


motion of the projectile. Then by what goes before, it appears that the resistance of the air will impart to the centre of gravity *G* of the projectile a motion of *translation* from the tangent *ot* in the plane of the paper, and towards that side, where the apex of the projectile is found. Also the resultant pressure of the air on the projectile will cut the axis between *G* and the apex of the shot. This will tend to increase the angle *tGa*, which however it will not affect sensibly, but will cause the axis *Ga* to *rotate* about the tangent *Gt*, in the same direction as the projectile rotates about its own axis.

[1] Traité de Balistique, p. 236. [2] Ib. p. 239.

141. The attention of Magnus seems to have been confined to the explanation of *lateral* drift of elongated projectiles. But his explanation of that phenomenon requires in addition the consideration of a drift in the *vertical* direction. It also appears to be a common notion that, if an elongated projectile is *perfectly steady* when it leaves a rifled gun, it will continue to move on steadily in the direction of its axis. It is not so, however, for suppose OT, Fig. 11, to be the direction of projection, the rapid

Fig. 11.



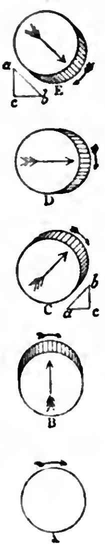
rotation of the projectile about its axis will tend to keep that axis ab parallel to OT. But the action of gravity upon the projectile will cause G, its centre of gravity, to move in a curve, so that the axis ba will become inclined to Gt the direction of motion of G. The resistance of the air will thus impart a motion of *translation* to the projectile *upwards*, and will also cause Ga to begin to describe a conical surface about Gt, as already explained. This *vertical* drift is the origin of all drift in a steady projectile.

142. Didion noticed a drift of elongated projectiles in a *vertical* direction, and in a practical case remarked it was equivalent to a reduction in the force of gravity in the ratio of 9·809 to 7·72, and then he adds the remark "Outre cette dérivation "*verticale* il en existe une autre, qui est *horizontale*, et du même "genre, et qu'il importe aussi de connaître, afin de diriger le tir "en conséquence[1]."

143. Various successive positions assumed by an elongated projectile shortly after it leaves the rifled gun are shown by the

[1] Traité de Balistique, 1860, p. 441.

Fig. 12.



diagrams A, B, C, D and E, Fig. 12, when viewed by an eye looking in a direction parallel to the tangent to the trajectory in each case. The curved arrows denote the direction of rotation of the projectile about its own axis, and the straight arrows show the direction in which the resistance of the air acting on the side of the projectile produces a motion of translation of the projectile. When a steady projectile has just left the gun, its base only would be seen, as in diagram A. After a short time the Figure B would represent the appearance of the projectile, where the drift would be entirely in a vertical direction, and *upwards* as denoted by the arrow: and the resistance of the air would cause the point of the projectile to begin to turn to the right. In a short time after, Figure C would represent the state of the case. Here the drift would be in the direction denoted by the arrow. If *ab* be taken to represent the drift in magnitude and direction at this time, then it may be resolved into a horizontal drift *ac* to the right, and a vertical drift *cb* upwards. The axis of the projectile will go on rotating about the tangent to the trajectory till the projectile comes into the position D, where the drift is entirely horizontal and to the right as indicated by the arrow. When the projectile has come to the position D the circumstances of the case will change slowly, for the tangent *Gt* to the trajectory is always dipping downwards, and the action of the resistance of the air in this case will cause the axis of the shot *Ga* also to dip downwards. If the tangent *Gt* dips more rapidly than the axis *Ga*, then the projectile will tend to return to the position shown in Figure C, and the motion will become oscillatory as in the case mentioned by Mayevski (139). This will be likely to happen when the trajectory is much curved, that is, when the velocity of the projectile is low as in the case referred to. But if the axis *Ga* dips faster than the tangent *Gt*, then the projectile will take the position represented by Figure E, where the drift will be in the direction indicated by the arrow. And if *ab* represent the drift in magnitude and direction, it may be resolved into a drift *ac* vertically downwards, and *cb* horizontally to the right. And afterwards the axis *Ga* may go on rotating about the tangent *Gt* and complete one or more revolutions. It should be observed that when the point of the shot is to the right of the vertical plane passing through the tangent, the tangent *Gt* to the trajectory and the axis *Ga* of the projectile are *both dipping downwards*, the rotation of the shot about its own axis being right handed as we have supposed. But when the apex of the projectile is to the left of the vertical plane through the tangent, the tangent *Gt* is *dipping downwards* but the axis *Ga* is *rising upwards*. Hence we may conclude that the drift will be in operation a much longer time to the right than to the left, when the projectile has a right-handed rotation about its own axis.

144. We thus find that the drift *upwards* is the beginning of all drift, and continues in operation from A to B. After passing the position B the drift upwards gradually decreases and vanishes at the position D. But the *horizontal* drift begins to make its appearance as soon as the projectile leaves the position B and gradually increases till it comes to the position D.

145. There can therefore no longer be any doubt that an elongated projectile, although it may leave the gun with perfect steadiness, soon begins to acquire the gyratory motion described by Magnus, St-Robert and Mayevski. At any instant the resistance of the air endeavours to push the projectile bodily from the tangent to its trajectory towards that side on which the apex of the projectile is situated (140). If the axis of the projectile makes one or more complete revolutions about the tangent to the trajectory then there will be a drift in every direction as seen from the gun. But we have no reason to assume that the sum of the *vertical* drift will vanish, so that the resultant drift will be entirely horizontal. With a right-hand rotation of the projectile, although there may be at times a drift to the left, that is very much exceeded by the drift to the right. So also there may be a drift downwards as well as upwards, but it seems to me that the total drift both in a *vertical* and *horizontal* direction will be in a great measure determined by what takes place near the gun, or while the projectile passes at a high velocity from position A to D, Fig. 12, and consequently that the projectile will be lifted up and made to move as if it had been fired at a somewhat higher elevation.

146. From what has been said, it appears to be necessary in calculating trajectories to allow an increase of elevation on account of the *vertical* drift, just in the same manner as the "jump" of the gun is allowed for. But this correction will not be quite so satisfactory, because the *vertical* drift does not act instantaneously at the muzzle, but goes on accumulating gradually while the projectile is moving in its trajectory, as already explained (143).

147. As the diagrams A, B, C, D and E, Fig. 12, represent the cross sections of the path swept out by the elongated projectile in its passage through the air, it is evident that, strictly speaking, the sectional area of the projectile at A will afterwards require to be increased, or that the coefficients of resistance must be *increased*, and not diminished according to Krupp's doctrine. It may also be remarked that as the projectile rises, the density of the air and therefore its resistance will diminish, and Tables XX. and XXI. have been prepared to assist in introducing the necessary corrections. But when the projectile rises only to a moderate height, the reduced resistance on this account may be supposed to balance the increased resistance arising from the inclination of the axis of the projectile to the direction of its motion. In such a case, however, a small reduction in the coefficients of resistance will be proper, if the head of the projectile be more pointed than an ogival struck with a radius of one diameter and a half.

148. I have calculated the following ranges for comparison with the Range Tables of the 4-inch B.L. gun, making $d = 4$ in.; $w = 25$ lbs.; muzzle velocity = 1900 f.s.; jump 6 minutes. In the first Table I have arranged the results so as to show the comparative ranges and times of flight, given by calculation and experiment for elevations of 1° to 15°. In these calculations the coefficients of Table IV. were used, which were obtained from experiments with ogival-headed shot struck with a radius of one diameter and a half, and no allowance was made for the decreasing density of the air, or for a more acutely pointed shot.

Elevation	Range			Time of Flight		
	By R. Table	By Calculation	Difference	By R. Table	By Calculation	Difference
	yards	yards	yards			
1°	1083	1049	−34	1″·97	1″·93	−0″·04
2	1811	1817	+6	3″·72	3″·71	−0″·01
3	2400	2406	+6	5″·34	5″·34	0″·00
4	2917	2901	−16	6″·93	6″·84	−0″·09
5	3392	3338	−54	8″·44	8″·24	−0″·20
6	3820	3738	−82	9″·85	9″·58	−0″·27
7	4213	4074	−139	11″·28	10″·90	−0″·38
8	4576	4432	−144	12″·65	12″·14	−0″·51
9	4905	4741	−164	13″·93	13″·36	−0″·57
10	5215	5027	−188	15″·16	14″·55	−0″·61
11	5514	5307	−207	16″·39	15″·73	−0″·66
12	5800	5562	−238	17″·50	16″·86	−0″·64
13	6086	5804	−282	18″·84	17″·99	−0″·85
14	......	......	......	....	....	....
15	6608	6249	−359	21″·34	20″·22	−1″·12

149. I have taken from the Range Table the elevations and times of flight corresponding to the above ranges obtained by calculation. I have also used the horizontal muzzle velocities in calculating by the General Tables the times over the same ranges, and the remaining velocities. The results are stated in the following Table:

Range	Elevation			Time of Flight			Calc. Horizontal Striking Velocity	General Tables	
	By R. Table	By Calculation	Difference	By R. Table	By Calculation	Difference		Time	Horizontal Velocity
yards							y. s.		y. s.
1049	0° 58′	1°	+0° 2′	1″·90	1″·93	+0″·03	476	1″·92	474
1817	2° 1′	2°	−0° 1′	3″·73	3″·71	−0″·02	386	3″·72	386
2406	3° 1′	3°	−0° 1′	5″·36	5″·34	−0″·02	340	5″·35	342
2901	3° 58′	4°	+0° 2′	6″·86	6″·84	−0″·02	319	6″·85	319
3338	4° 53′	5°	+0° 7′	8″·26	8″·24	−0″·02	302	8″·28	301
3738	5° 48′	6°	+0° 12′	9″·57	9″·58	+0″·01	289	9″·65	286
4074	6° 38′	7°	+0° 22′	10″·76	10″·90	+0″·14	274	10″·86	275
4432	7° 35′	8°	+0° 25′	12″·10	12″·14	+0″·04	265	12″·22	263
4741	8° 29′	9°	+0° 31′	13″·29	13″·36	+0″·07	255	13″·44	254
5027	9° 23′	10°	+0° 37′	14″·41	14″·55	+0″·14	246	14″·61	246
5307	10° 18′	11°	+0° 42′	15″·53	15″·73	+0″·20	238	15″·80	237
5562	11° 10′	12°	+0° 50′	16″·67	16″·86	+0″·19	231	16″·94	230
5804	12° 1′	13°	+0° 59′	17″·52	17″·99	+0″·47	225	18″·04	223
.....	....	.....	....	....	....	....	.....	....	.....
6249	13° 36′	15°	+1° 24′	19″·55	20″·22	+0″·67	208	20″·19	211

Here the difference of elevations in each case seems to be the correction required for vertical drift, inasmuch as that correction gives both ranges and times of flight satisfactorily.

150. It must be borne in mind that my coefficients of resistance were mostly derived from the motion of ogival-headed projectiles fired through ten screens placed 50 yards apart, at elevations calculated to give ranges of 600 or 700 yards. Those projectiles, which passed through all the ten screens, must in general have been steady in their flight. The 5-inch gun was a remarkably good one, which by its accurate shooting gave many records, and consequently many values of the coefficient K for velocities between 1000 and 1650 f.s. But those projectiles, which were unsteady, passed through only a few screens giving very few records, and therefore they could have only a very limited effect on the final results. The coefficients of resistance for velocities 1000 to 1650 f.s. were derived from experiments made with ogival-headed projectiles in 1867, 8 by the use of 3, 5, 7 and 9-inch M.L. guns. This variation in the calibres of the guns was adopted because it was necessary to ascertain in the first place, whether the resistance of the air did really vary as the square of the diameter of the projectile. That law having been found satisfactory, the coefficients of resistance for velocities 1650 to 2250 f.s. were obtained by experiments in 1878, 9 with a new 6-inch B.L. Armstrong gun, and in 1880 these coefficients were extended to velocity 2780 f.s. by experiments made with a new 8-inch B.L. Armstrong gun. The results given by these two guns proved perfectly consistent, as will be found by comparing the Report of Experiments printed in 1879 with the Final Report of 1880. I have the best authority for stating that no English guns constructed since 1880 have hitherto given evidence of any marked improvement in the centering of their projectiles. Numerous examples have been worked out to explain the use of the Tables, and to show how well the calculated agree with the experimental results of recent guns, so long as the elevation of the gun is low, for in that case the projectiles move nearly in the direction of their axes, and *much as they did when my experiments were made.* These comparisons of calculated and experimental results have been found perfectly satisfactory for velocities 1900 to 960 f.s. and for ranges up to 3000 yards. That is full and complete evidence of the accuracy of my coefficients of resistance.

151. As the elevation of the 4-inch gun goes on increasing above 4°, the calculated ranges and times of flight gradually fall short more and more of these values given in the Range Table for the specified elevation (148), but they are consistent with those given for a somewhat lower elevation (149). There is no reason for supposing that the resistance of the air to an elongated projectile fired at an elevation greater than 4° is less than that to the same projectile fired at a lower elevation, excepting for the decreasing density of the air for which special provision has to be made (92). Certainly this discrepancy cannot be corrected by simply reducing the coefficients of resistance as Captain May, R.N., has discovered. For he has observed that "...when the "coefficients used in calculating the time of flight *are the same* "as those which were found to give results agreeing with practice "when used for the calculation of the range, it has *often* been "found that the *calculated time* falls short of the *observed time;* "this would seem to point to the range being prolonged by a "kite-like action of the shell, and if this is so, it may be that "the coefficients which give bad results when applied to the cal-"culation of the range *may not be so erroneous as they appear*[1]."

If the experiments here referred to were good, and if my coefficients had been reduced 5, 10 or 15 per cent.[2] to make the calculated agree with the observed range, it might naturally be expected that the calculated time of flight would fall short of the observed time of flight—because the resistance of the air to the projectile had been unduly reduced. But if my coefficients of resistance had been *properly used,* I feel satisfied that, if not for the given elevation, then for some slightly reduced elevation the calculated range and time of flight would have been found consistent with experiment as in (149). And the proper way to bring calculation into agreement with experiment will be, to make the necessary addition to the elevation, which is accounted for by the *vertical* drift or "the kite-like action" of the shell (143).

152. From the note Captain May appends, I fear he has also made use of some faulty methods of calculation, for he remarks:—"Curiously enough it is usually at comparatively short "ranges, where the trajectory is but little curved that the ob-

[1] Proceedings of the R. A. Inst. xiv. p. 369. [2] Ib. p. 364.

"served time of flight has been found to differ most from the "calculated time. At longer ranges with the same gun they "often agree well[1]." Now I have calculated ranges and times of flight for Captain May's own model Range Table[2] for elevations of 1°, 2°, 3° and 4° the full extent of his Table, and found throughout a most precise agreement between calculation and experiment up to a range of 4000 yards (123). This being the case for low elevations, confirmed by the General Tables (124), I cannot suppose that projectiles fired at higher elevations would require any reduction in the coefficients of resistance, except as above observed so far as the density of the air becomes reduced, and for that I have prepared special corrections.

153. Special experiments were made with the 4-inch B.L. gun in 1887 to test my coefficients of resistance on a long range. I have no confidence in velocities measured by *galvanic* chronographs at considerable distances from the gun. Therefore the initial velocity of each round and the time of flight over a range of 2000 to 3000 yards were measured by the same chronograph, and afterwards the mean experimental and mean calculated times of flight were compared. The results showed that the coefficients were quite satisfactory, as we have found them to be by the use of the Range Table of the same gun for even longer Ranges (125) and (126).

[1] Proceedings of the R. A. Inst. XIV. p. 369. [2] Ib. p. 356.

CHAPTER VII.

PROPOSED LAWS OF THE RESISTANCE OF THE AIR TO ELONGATED PROJECTILES.

154. MY method of experimenting gave the coefficients of resistance in a form directly applicable to the calculation of General Tables and trajectories. The expression of the law of resistance of the air in terms of the velocity of the projectile was not therefore required for my own purposes. But as such laws seemed to be desired, I endeavoured to give them from time to time for ogival-headed projectiles. The average of the times at which the equidistant screens were passed in the trial of the instrument in 1865 gave a value of $\Delta^2 t$ nearly constant, and thence it was inferred that the resistance varied approximately as the cube of the velocity (38)[1].

155. As there have been many laws of resistance published for ogival-headed projectiles since the commencement of my ballistic experiments, I now propose to state them in the order in which the principal of them appeared and also to apply them, as far as possible, to calculate a standard example, which has been already used for a similar purpose by Major Mackinlay, R.A.[2]. The problem will be to find in each case, by the General Tables, in what Range a 10-inch, or 25·4 c.m. ogival-headed projectile would have its velocity reduced :

(i) from 1700 to 1300 f.s.; or from 518·15 to 396·23 m.s., and

(ii) from 1300 to 1100 f.s.; or from 396·23 to 335·27 m.s. where $w = 412·54$ lbs., or 187·12 kgs. which give

$$d^2 \div w = 0·2424.$$

[1] Reports, &c. 1865—1870, p. 8. [2] Proceedings of the R. A. Inst. XIV. p. 18.

The ranges calculated by the English Tables will be reduced to the French standard, where $\omega = 527$ grains.

156. We have seen, (106), that my Tables published in 1868, when applied to the 10-inch ogival-headed shell, gave a reduction

(i) from 1700 to 1300 f.s. in velocity in a range of 2534 yards, when reduced to the French standard. And

(ii) from 1300 to 1100 f.s. in a range of 1781 yards......(*a*).

In 1871, from the results of my experiments in 1867, 8[1], I stated that for ogival-headed projectiles, the resistance of the air might be taken to vary roughly as follows:

$$\left.\begin{array}{ll} v \qquad > 1350 \text{ f.s.}; & f \propto v^2 \\ v < 1350 > 1100 \text{ f.s.}; & f \propto v^3 \\ v < 1100 > \ \ 900 \text{ f.s.}; & f \propto v^6 \end{array}\right\} \ldots\ldots\ldots\ldots\ldots(b).$$

My General Table, 1871, gave ranges

(i) of 2584 yards,

and (ii) of 1789 yards.

157. The formulæ deduced by Mayevski[2] from the so-called "résultats des expériences *russes* et anglaises" 1872 were

$$\left.\begin{array}{llll} v < 510 > 360 \text{ m.s.}; & \text{or } < 1673 > 1181 \text{ f.s.}; & f \propto v^2 \\ v < 360 > 280 \text{ m.s.}; & \text{or } < 1181 > \ \ 919 \text{ f.s.}; & f \propto v^6 \\ v < 280 > \quad 0 \quad ; & \text{or } < \ \ 919 > \quad 0 \quad ; & f \propto v^2 \left\{1 + \left(\dfrac{v}{488}\right)^2\right\} \end{array}\right\} \ldots\ldots\ldots(c).$$

158. My General Tables recalculated in 1873[3] gave ranges

(i) of 2583 yards,

and (ii) of 1790 yards.

The experiments made with my chronograph 1878, 9[4] gave in addition to the laws (*b*),

$$\left.\begin{array}{ll} v < 1010 > 830 \text{ f.s.}; & f \propto v^3 \\ v < \ \ 830 > 430 \text{ f.s.}; & f \propto v^2 \end{array}\right\} \ldots\ldots\ldots\ldots\ldots(d),$$

and

[1] Remaining Velocities, 1871, p. 48, and Proceedings of the R. A. Inst. VII. p. 392.

[2] Traité de Balistique, p. 42.

[3] Motion of Projectiles.

[4] Report, &c. Part II. 1879.

and the General Table founded on these experiments gave ranges (i) of 2584 yards,

and (ii) of 1785 yards.

159. When Siacci published his Ballistic Tables, (1880), he professed to have founded them upon the so-called "*russe* ed "inglesi" results, but he modified Mayevski's laws[1] (*c*), and brought them more nearly into agreement with my laws (*b*) and (*d*), except for low velocities, as follows:

$$\left.\begin{array}{llll} v < 520 > 420 \text{ m.s.}; & \text{or } < 1706 > 1378 \text{ f.s.}; & f \propto v^2 \\ v < 420 > 343 \text{ m.s.}; & \text{or } < 1378 > 1125 \text{ f.s.}; & f \propto v^3 \\ v < 343 > 280 \text{ m.s.}; & \text{or } < 1125 > 919 \text{ f.s.}; & f \propto v^6 \\ v < 280 > 0 \text{ m.s.}; & \text{or } < 919 > 0 \text{ f.s.}; & f \propto v^2 \left\{1 + \left(\frac{v}{495 \cdot 1}\right)^2\right\} \end{array}\right\} \quad \ldots\ldots\ldots\ldots (e).$$

Siacci's Table $D(v)$, 1880, gives ranges

(i) of 2522 yards,

and (ii) of 1814 yards.

160. Krupp did not attempt to assign any laws of resistance, but they differed little from my own, when my coefficients were reduced 9 or 10 per cent. His Table (1881), gives ranges

(i) of 2847 yards,

and (ii) of 2209 yards.

161. Mayevski (1883), professes to have deduced certain laws from Krupp's Meppen experiments which Ingalls has expressed as follows in English measure[2]:

$$\left.\begin{array}{ll} v < 2300 > 1370 \text{ f.s.}; & f \propto v^2 \\ v < 1370 > 1230 \text{ f.s.}; & f \propto v^3 \\ v < 1230 > 970 \text{ f.s.}; & f \propto v^5 \\ v < 970 > 790 \text{ f.s.}; & f \propto v^3 \\ v < 790 > 0 \text{ f.s.}; & f \propto v^2 \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots (f).$$

The Mayevski-Krupp Table (1873), gives ranges

(i) of 2819 yards,

and (ii) of 2176 yards.

[1] Giornale d' Artiglieria, 1880. [2] Exterior Ballistics, p. 29.

Here it is manifest that Mayevski completely abandons his original laws (*c*) and approximates to my laws (*b*) and (*d*).

162. Hojel professes to have deduced similar laws from the same experiments, upon which Ingalls remarks[1], that "Hojel has "considered it necessary to employ *fractional exponents,* thereby "sacrificing simplicity without apparently gaining in accuracy." He afterwards compared the results given by the formulæ of Mayevski and Hojel, and by the "Table de Krupp" for velocities 2300 to 400 f.s. and found they agreed[2], so that we may take the law expressed by Mayevski to represent all three.

163. From my Final Report (1880), I deduced the following laws[3]:

$$\begin{aligned} v \qquad\qquad &> 1300 \text{ f.s.}; \; f \propto v^2, \\ v < 1300 &> 1100 \text{ f.s.}; \; f \propto v^3, \\ v < 1100 &> 1040 \text{ f.s.}; \; f \propto v^6, \\ v < 1040 &> 850 \text{ f.s.}; \; f \propto v^3, \\ v < 850 &> 100 \text{ f.s.}; \; f \propto v^2. \end{aligned}$$

164. Ingalls[4] has deduced the following laws from the same Report, 1880:

$$\left.\begin{aligned} v \qquad\qquad &> 1330 \text{ f.s.}; \; f \propto v^2 \\ v < 1330 &> 1120 \text{ f.s.}; \; f \propto v^3 \\ v < 1120 &> 990 \text{ f.s.}; \; f \propto v^6 \\ v < 990 &> 790 \text{ f.s.}; \; f \propto v^3 \\ v < 790 &> 100 \text{ f.s.}; \; f \propto v^2 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (g).$$

Ingalls employed these results when he calculated his Tables, which give ranges

(i) of 2595 yards,

and (ii) of 1775 yards.

My own General Tables, (1889), give ranges

(i) of 2566 yards,

and (ii) of 1781 yards.

[1] Exterior Ballistics, p. 30.

[2] Ib. p. 31.

[3] Nature, XXXIII. p. 605.

[4] Exterior Ballistics, 1886, p. 36.

My Laws of Resistance (1889), finally adopted after the recent revision of all my experiments, will be found in Tables (III) and (IV).

165. The following is a summary of the results above obtained:

Reduction of velocity	(I) from 1700 f.s. to 1300 f.s.	(II) from 1300 f.s. to 1100 f.s.	or (III) from 1700 f.s. to 1100 f.s.
Bashforth 1868,	2534 yards,	1781 yards;	or 4315 yards
„ 1871,	2584 „ ,	1789 „ ;	or 4373 „
„ 1873,	2583 „ ,	1790 „ ;	or 4373 „
„ 1879,	2584 „ ,	1785 „ ;	or 4369 „
Siacci 1880,	2522 „ ,	1814 „ ;	or 4336 „
Krupp 1881,	2847 „ ,	2209 „ ;	or 5056 „
Mayevski 1883,	2819 „ ,	2176 „ ;	or 4995 „
Ingalls 1886,	2595 „ ,	1775 „ ;	or 4370 „
Bashforth 1889,	2566 „ ,	1781 „ ;	or 4347 „

I have now noticed in chronological order the works of those writers on Ballistics mentioned by Ingalls as the authors of Ballistic Tables or of Laws of Resistance of the air to the Motion of Projectiles.

CHAPTER VIII.

CONCLUDING REMARKS.

166. As the accuracy of my coefficients of resistance has been questioned, I have gone carefully over all my experimental rounds (53)—(72) and given full particulars of the values of K so obtained (73)—(81). I have also used the means of these coefficients to calculate by Bernoulli's exact method the ranges and times of flight of projectiles fired from the 4-inch B.L. gun (125). The General Tables have also been used to calculate the times of flight of projectiles fired from the same gun (126).

And similar calculations have been made for the 12-inch B.L. gun (123). In every case the agreement between calculation and experiment has been found to be far closer than could reasonably have been expected. The natural conclusion seems to be that my coefficients are well adapted for the calculation of the motion of elongated projectiles fired from *recent* guns for ranges of these guns up to 3000 or 4000 yards, and therefore for all ranges so long as the motion of the projectile in practice corresponds to the motion of the projectiles in my experiments, that is, so long as the projectile moves nearly in the direction of its axis.

167. But as the elevation of the gun increases above 4° or 5° the vertical drift (141) coming into action raises up the elongated projectile so as to give an increased range and time of flight. In such cases my proposal is to *correct the elevation* so that the calculated range and time of flight may agree with those observed quantities. By the careful calculation of good Range Tables it is probable that the law of vertical drift might be

ascertained for elongated projectiles. On the other hand it has been proposed by the Krupp party to *reduce my coefficients* of resistance. But this mode of correcting for range has been found to give too short a time of flight (151), and consequently an erroneous striking velocity. We may now proceed to consider on what authority this proposed reduction of my coefficients depends.

168. Mayevski published the results of some few rounds in 1872, for both spherical and ogival-headed shot[1] accompanied by a statement that these experiments were made in 1868, 9. "Les "expériences de St Pétersbourg sur la résistance de l'air au "mouvement des projectiles *sphériques* et oblongs ont été faites "par nous en 1868 et 1869 et *leurs résultats sont pour la première "fois publiés dans notre traité*" (1872). "Afin que les expressions "de la résistance représentent, avec une approximation suffisante, "les résultats de *nos expériences et ceux des expériences anglaises, "faites avec des appareils perfectionnés*...pour les *projectiles sphé- "riques*...pour les *projectiles* oblongs[2]."

Thus Mayevski both here in his preface and in his work fully acknowledges the use he had made of my published results, for he remarks "Aussi pour compléter les données se rapportant "aux projectiles de forts calibres nous avons profité des tableaux

[1] NOTE. The following is a statement of *all the results* of experiments given by Mayevski for both spherical and oblong projectiles in his Balistique Extérieure, 1872, p. 39.

v m. s.	ρ'	v m. s.	ρ'	v m. s.	ρ'	v m. s.	ρ'	v m. s.	ρ'
Spherical Projectiles.									
227	0,0295	278	0,0424	341	0,0519	384	0,0602	457	0,0598
234	0,0267	287	0,0411	342	0,0582	408	0,0587	463	0,0611
262	0,0361	330	0,0491	380	0,0554	415	0,0625	475	0,0625
								527	0,0619
Oblong Projectiles.									
172	0,0151	247	0,0170	304	0,0221	319	0,0174	337	0,0341
207	0,0137	266	0,0160	307	0,0158	320	0,0299	360	0,0384
239	0,0148	282	0,0163	317	0,0259	329	0,0338	401	0,0450
								409	0,0430

[2] Traité de Balistique extérieure, 1872, p. vi.

"des vitesses décroissantes[1] déduites par M. Bashforth de ses ex-"périences faites en 1868 au moyen de son chronographe...Nous "avons calculé d'après les résultats insérés dans ces tableaux les "valeurs de la résistance correspondantes à différentes vitesses[2]."

169. Afterwards Mayevski gives in a tabular form some values of Didion's ρ' derived from the published results of my labours, as well as those he had deduced from his own experiments[3], the former being more numerous than the latter. So far everything was as it should be. But unfortunately, immediately afterwards Mayevski spoke of this compound as "les ré-"sultats des expériences *russes* et anglaises." And Siacci in publishing his Ballistic Tables (1880), copied the above-mentioned Table, saying "ecco i resultati dell' esperienze *russe* ed inglesi." And again Siacci in his Balistica (1884), gives a second copy of this precious Table of "esperienze *russe* ed inglesi[4]." Siacci ought to have known that the English experiments were complete in themselves and were published long before Mayevski concocted his Law of Resistance. But to show clearly the value of the Russian element, I have used Siacci's own Table D (v), said to have been derived from the results "*russe* ed inglesi" to recalculate one of my Tables of decreasing velocities published in 1868, *which Mayevski avowedly made use of* and which has already been reprinted in full (104).

Distances	Decreasing Velocities		
Feet	Bashforth's Report, 1868	Mayevski, 1872, by Siacci's Table	Differences
100	1706 *f. s.*	1706 *f. s.*	0 *f. s.*
1100	1603	1605	+2
2100	1509	1509	0
3100	1419	1420	+1
4100	1336	1336	0
5100	1259	1261	+2
6100	1189	1194	+5
7100	1129	1134	+5
8100	1076	1082	+6
9100	1034	1040	+6
10100	1002	1005	+3

[1] Proceedings of the R. A. Inst. Notes, 1868.

[2] Mayevski, Traité de Balistique, 1872, p. 38.

[3] Ib. p. 41, and Note (168).

[4] Balistica, III. p. 4.

This shows clearly that the effect of the Russian experiments was *nil,* and consequently that Mayevski merely adopted in 1872 my results published in 1868. When experimenters publish the results of their laborious investigations, they know that their results are always open to be tested and examined by any one qualified for such work, but in no case have I met with such a flagrant attempt to appropriate the chief share in the already published work of another.

170. We will now proceed to test Mayevski's experiments with spherical projectiles (1872) in the same manner. In the Report on my experiments with spherical projectiles (1869) a Table of decreasing velocities was given for all the service spherical projectiles (105), just as in the case of the ogival-headed shot above referred to. As Captain Ingalls has used Mayevski's results in preparing Tables for his edition of Siacci's method of calculating trajectories of *spherical* projectiles, I am thus enabled to give a Table of decreasing velocities calculated after Mayevski's results for spherical projectiles (1872) for the 100-Pr. gun at intervals of 1000 feet ($d^2 \div w = 0{\cdot}7766$) for comparison with my own Table published in 1869 as follows:

Distances	Decreasing Velocities		
Feet	Bashforth's Report, 1869	Mayevski, 1872, by Ingall's Table	Differences
400	1970 *f. s.*	1970 *f. s.*	0 *f. s.*
1400	1680	1682	+ 2
2400	1437	1436	− 1
3400	1236	1226	− 10
4400	1078	1066	− 12
5400	962	950	− 12
6000	906	893	− 13

Here again we have very trifling differences, showing that Mayevski's experiments with spherical shot published in 1872, gave just the same results for all practical purposes as my coefficients gave which were published in 1870.

Hence it appears that the only value of Mayevski's experiments is, so far as they go, to *confirm my previously published coefficients* for both spherical and ogival-headed projectiles.

171. Major Siacci inserted the following note in his Balistica (1884), "La prima tavola balistica fu calcolata sulla base delle "formole (2) della Nota I. dal maggiore Siacci, pubblicando il "*Nuovo Metodo* (*Giornale d' Artiglieria e Genio* P. II. 1880). Un' "altra tavola balistica fondata sulle stesse formole, ma con unità "inglesi, fu calcolata dal tenente Mitcham degli S.U. d' America "(Ordnance Note n. 152). Una terza tavola colle stesse formole "è dovuta al Capitano M. Ingalls degli S.U., il quale ha calco-"lato anche una tavola balistica sui proietti sferici (*Ballistics,* "*Fort Monroe Virginia,* 1883). La casa Krupp ha pubblicato "anche una estesa tavola balistica sulla base delle formole (3) "della Nota I (*Ballistische Formeln von Mayevski, nach Siacci,* "*Essen,* 1883), &c.[1]"

172. Here we find no reference to similar Tables published in England in 1871, 2, 3, 7 &c. for both spherical and ogival-headed projectiles (106)—(110). The simple fact is that Major Siacci uses four Tables in his approximate method of calculating trajectories, three of which had been previously in use in this country, and were well known.

Siacci's Table D (u) 1880 is the same as my Table $\frac{d^2}{w} s$, 1871,

" " T (u) 1880 " " " $\frac{d^2}{w} t$, 1872,

" " J (u) 1880 " " Niven's $D_v \frac{\pi}{180}$, 1877.

My two General Tables were adapted by me for use when the path of the projectile *approximated to a straight line.* And Professor Niven afterwards applied these two tables, with the help of a third table D_v of his own to the calculation of flat trajectories in 1877.[2] These simple matters of fact ought to have been mentioned by Major Siacci, as he pretended to give a history of the tables, for his statement of the case as above quoted is misleading.

173. Captain Ingalls has pointed out certain grave difficulties in the use of Siacci's Equations for Direct Fire, as follows: "As

[1] Balistica, 1884, p. 63.
[2] Proceedings of the Royal Society, 1877.

"already stated, α is some mean value of the secants of the in-"clinations of the extremities of the arc of the trajectory over "which we integrate, and consequently if we take the whole "trajectory lying above the level of the gun, α will be greater "than 1 and less than sec ω. To illustrate, suppose we have for "our data a given projectile fired with a certain known initial "velocity and angle of projection, and we wish to calculate the "angle of fall, terminal velocity, range and time of flight. If "we calculate these elements by means of (75), (72), (76) and "(77) making $\alpha = 1$, they will be too great; while if α is made "equal to sec ω, or even sec ϕ they will be too small; and the "correct value of each element would be found by giving to α "*some* value *intermediate to the two.* Moreover, the value of α, "which would *give the exact range* would *not give the exact time of* "flight or terminal velocity"[1]! It must be very evident that the approximate calculation of trajectories by Siacci's method as above described, or any similar method involving the use of an arbitrary value of "α," cannot be recognised by me as any test whatever of the correctness of my coefficients.

174. It appears[2] that in a recent edition of his Tables, Siacci has given up what he was pleased to name "esperienze *russe* ed "inglesi" and has adopted the laws of resistance which Mayevski professes to have deduced from Krupp's experiments, although he has confessed that "Io non conosco i particolari d' esecuzione "delle sperienze Krupp, nè il metodo con cui furono calcolate le "due tabelle[3]."

175. The late Mr Krupp was famous for his method of employing steel in the construction of big guns, but he appeared in quite a new character as the nominal author of Ballistic Tables in 1881. The second part of the Reports on experiments made by my chronograph, with the help of the first part, 1868, 9, gave coefficients of resistance to ogival-headed projectiles for all velocities between 430 and 2250 f.s., or between 131 and 686 m.s., which were made use of in calculating General Tables 1879. In 1881 Krupp printed in French and German some Ballistic Tables

[1] Exterior Ballistics, p. 115.
[2] Proceedings of the R. A. Inst. xvii. p. 86.
[3] Giornale d' Artiglieria, Pt 2, 1881.

of the same kind as my own which extended from velocity 140 to 700 m.s. But no particulars were given of the experiments, from which he professed to derive materials for his Tables. He merely stated that his Table "a été établi par l'usine Krupp au com-"mencement de l'année 1880," but he did not condescend to particulars, neither did he refer to my results printed two years previously. Having stated that it had been found that no satisfactory general law of resistance of the air as function of the velocity could be found, he then remarked "Cette expérience "devait le faire paraître utile de trouver *une nouvelle* méthode "pour le calcul des vitesses restantes. *Cette méthode a été "trouvée de la manière suivante.*" This is quite erroneous as explained (89). For the same method had been previously discovered in a different manner and published, and had been in regular use in England during the preceding ten years 1871—1881. Early copies of these Tables of Krupp were sent over to the United States, America, where they were at once translated, but I was not able to obtain a sight of the precious work till Dec. 1883, and that copy arrived in this country *viâ* America. I then found that Krupp's Tables were based on my Laws of Resistance (Fig. 13), but with the coefficients reduced about 9·3 per cent.[1] Afterwards it appears to have been felt that these Tables lacked support from experiment, for in the following year (1882) an "Annexe", which contained a statement of 37 rounds, apparently selected from old note books 1875 to 1881, was put forward to support the correctness of the so-called "Table de Krupp" (1881). But *in no case was the time of flight given*, and so there was wanting a most important test of accuracy. The chief particulars of the experiments will be found in the accompanying Table (see next page), which also gives the results obtained by Captain Ingalls who recalculated each round of the "Annexe" (1) by Krupp's Table; (2) by his own table based on my results, reduced 9·3 per cent.; and (3) by formulæ of resistance which Mayevski professes to have deduced from Krupp's Meppen experiments.

. . . .

176. On these results Captain Ingalls has remarked that "The only discrepancies of any account between the calculated "velocities in this column (his own) and the observed velocities

[1] Proceedings of the R. A. Inst. XIII. p. 350.

No.	Dates	Projectiles: Calibre en mm.	Projectiles: Poids en kilogrammes	Poids de l'air en kilogrammes par m^3	Différences entre distances x_1 et x_2 auxquelles la vitesse fut mesurée en mètres	Vitesses mesurées des Projectiles v_1 et v_2 en mètres: v_1	v_2	Calculated Velocities: v Computed by Krupp m. s.	v Computed by Table I. m. s. $c=0·907$	v Computed by Mayevski's Formulas m. s.
1	16/11/75	240	125	1·245	1450	467	380	379·9	380·7	380·6
2	,,	,,	161	,,	,,	454·5	390	388·3	387·7	387·5
3	18/ 3/76	172·6	61·5	1·226	1389	477	388	388·7	389·3	388·7
4	24/ 3/76	,,	,,	,,	1429	514·7	416·6	417·9	417·6	415·7
5	2/ 3/76	149·1	39·3	1·260	,,	518	401·6	402·1	403·0	401·2
6	3/ 3/76	,,	33·5	1·240	,,	507·7	380	380·7	379·9	379·1
7	30/11/76	,,	31·3	1·265	924	475·8	387·8	388·2	387·7	387·3
8	2/ 7/78	355	525	1·200	1884	495·9	432·7	433·1	433·8	432·6
9	11/ 6/79	,,	,,	1·200	2384	490	415	411·8	414·4	412·3
10	20/ 6/79	,,	,,	1·200	2389	488·5	409·6	410·4	412·3	410·9
11	17/12/78	149·1	31·3	1·265	1950	609	394	393·9	395·4	392·7
12	7/ 8/79	,,	51	1·206	1929	505·2	394·6	393·3	393·4	392·3
13	9/ 8/78	152·4	51·5	1·205	1450	472·4	391·3	389·3	389·1	388·6
14	,,	,,	32·5	,,	,,	577	422	422·0	424·2	421·5
15	13/12/78	149·1	31·3	1·230	,,	632·4	460·9	460·3	462·8	459·8
16	25/ 6/79	240	215	1·208	1904	480·4	412·8	412·0	412·4	411·1
17	5/ 8/79	400	777	1·180	2384	499·4	433·7	432·1	433 0	431·7
18	6/ 8/79	,,	643	1·190	,,	533·4	443·8	447·0	448·2	446·6
19	,,	,,	,,	1·190	,,	531·5	444·5	445·4	446·6	445·0
20	6/10/76	84	6·55	1·197	2447	446·9	266	267·2	259·7	267·4
21	3/10/76	120	16·4	1·211	,,	463·3	284·1	289·2	281·6	289·3
22	12/12/78	149·1	31·3	1·285	3448	536·6	294·8	290·6	283·7	290·5
23	22/ 1/80	105	16	1·300	3436	481·5	282	278·4	271·2	279·6
24	17/ 1/80	96	12	1·340	3439	425·8	256·2	250·5	244·1	254·4
25	26/ 6/80	107	12·5	1·218	777·5	205·1	188·2	189·8	187·7	189·8
26	10/ 7/80	152·4	31·5	1·206	966·5	203	188	187·4	185·9	188·0
27	7/ 7/81	105	16	1·222	950	514·2	426·9	421·1	422·2	420·4
28	11/ 7/81	149·1	39	1·218	1429	470	369·5	370·4	369·1	369·3
29	23/ 6/77	283	234·7	1·206	4450	464·7	321·2	318·9	311·3	317·6
30	25/ 7/81	,,	,,	1·205	1879	465·3	403·9	403·3	404·6	403·7
31	26/ 7/81	,,	,,	1·200	1919	465·9	385·4	384·7	384·0	383·8
32	,,	,,	,,	,,	2425·5	466·5	370·6	368·0	366·6	367·0
33	27/ 7/81	,,	,,	1·220	2921·5	464·8	347·8	350·9	347·7	349·7
34	28/ 7/81	,,	,,	1·227	3426·0	463·7	336·0	337·6	331·4	336·6
35	29/ 7/81	,,	,,	1·220	4446·5	460·0	316·6	316·6	308·6	315·0
36	1/ 8/81	,,	,,	1·192	5945·0	455·8	295·0	293·9	285·6	293·0
37	4/ 8/81	,,	,,	1·206	,,	453·1	294·7	291·5	283·2	291 4

"occur where the curvature of the trajectory is considerable, as "in the last four rounds, and one or two others. Equation (30) is "based upon the supposition that the *path of the projectile is a* "*horizontal right* line, and of course, gives only *approximate results* "when this path has any appreciable curvature.... In No. 37, "for example, it will be found that to attain a range of 5945 metres "($3\frac{2}{3}$ miles) the angle of projection would have to be 12° 37′, and "the angle of fall would be 17° 40′[1]." Hence it appears that the result of Krupp's labours was a reduction of 9·3 per cent. in my coefficients, and the authority for that reduction depends entirely upon the 37 rounds given in Krupp's "Annexe."

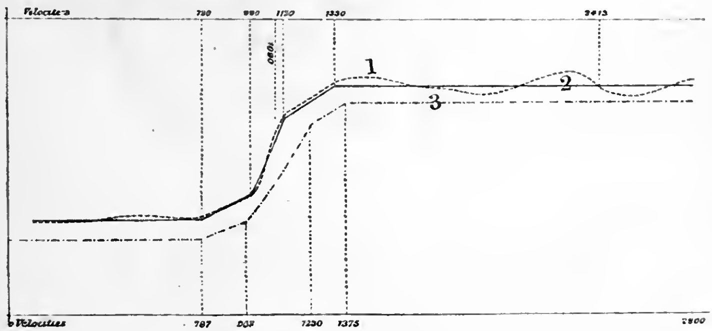
177. When it is desired to find the law of the resistance of the air to the motion of projectiles by the use of chronoscopes of the Navez type, it is necessary to measure the velocities of the projectiles at two points *near together*, and then the resistance required to produce the observed loss of velocity in the *given short range* is usually taken to be the resistance of the air to the projectile when moving with the *mean* of the two measured velocities. But not one of the ranges given in Krupp's Annexe is of moderate length, for they vary from 777 to 5945 metres. Nothing can therefore be known experimentally about the variation of the velocity between the two extremities of each range. Velocities measured at distant stations by chronoscopes have not been found satisfactory. Take the round mentioned in particular by Captain Ingalls (176); the rise in the trajectory near the gun would be 22 in the 100, and the fall at the distant end would be 32 in the 100. Here is a difficult problem to fire a projectile through a pair of screens near the gun and also through another pair 5945 metres off. And if this could be done, the resulting velocities would not be trustworthy under the circumstances above stated.

178. Notwithstanding all these difficulties Mayevski and Hojel have had the courage to attempt to deduce laws of resistance from the Meppen experiments. It appears to me that the only way to proceed in such a case, would be to take some previously determined law and adjust the coefficients so as to obtain the desired results. I have copied the following diagram[2], as it

[1] Proceedings of the R. A. Inst. XIII. p. 62. [2] Ib. XVII. p. 87.

shows clearly the state of the case. The dotted line (1) represents the results given by my experiments (1880); (2) the laws deduced from my experiments by Captain Ingalls[1] (164); and (3) the laws deduced by Mayevski (161), "when the Krupp projectile is "employed[2]". As Ingalls has used both the Krupp Table and

Fig. 13.



Mayevski's laws to calculate the rounds of the Annexe, and found a close agreement between them, (3) may be taken also to represent the laws of resistance on which Krupp's Tables are founded.

179. Immediately after my Report on the experiments of 1878, 9 was printed, it was decided to make experiments with still higher velocities. These experiments, carried out at Shoeburyness, March 8—10, 1880, extended the coefficients of resistance to ogival-headed projectiles to all velocities between 2250 and 2780 f.s., or between 686 and 850 m.s. The Report of these experiments was published 1880[3].

180. The following July experiments were professedly carried on at Meppen: "pour déterminer la résistance de l'air aux grandes "vitesses de projectile" Bulletin XXX. But in the end, all that was attempted was to try "si la résistance de l'air restait pro-"portionelle au carré de vitesse du projectile aussi pour les vi-"tesses de projectile plus grandes que celles expérimentées jus-"qu'ici." Here the details of each round have been given, so that we are able to judge how experiments of this nature were con-

[1] Exterior Ballistics, p. 36. [2] Ib. p. 28.
[3] Final Report.

ducted at Meppen. No less than *six* independent chronographs were used which were arranged so that one pair measured the velocity at station *A*, 30 metres, another pair at *B*, 130 metres, and the remaining pair at *C*, 500 to 1500 metres from the gun. Generally the two measures of the velocity at the *same point* differed considerably and much more than is allowed by the rule laid down by Ingalls, for he says that the difference in the velocities of each shot as determined by two instruments should not exceed one-thousandth of the actual velocity[1].

181. As a curiosity, I copy from Bulletin XXX. the worst group of all, which exceeds belief.

July 5, 1881.

	Measured velocity at *A* 30 metres from Gun by two Chronoscopes			Measured velocity at *B* 130 metres from Gun by two Chronoscopes			Measured velocity at *C* 1000 metres from Gun by Chronoscopes	
Round	No. 301	No. 302	Diff.	No. 292	No. 293	Diff.	No. 114	No. 115
7	896·4	892·5	+ 3·9	855·9	850·9	+ 5·0	nil.	nil.
8	903·8	894·5	+ 9·3	852·7	862·7	− 10·0	nil.	nil.
9	907·4	887·2	+ 20·2	857·6	856·7	+ 0·9	438·1	nil.
10	907·4	911·4	− 4·0	854·1	834·7	+ 19·4	nil.	nil.
Means	903·8	896·4	+ 7·4	855·1	851·3	+ 3·8	438·1	nil.
Means of means	900·1 m. s.			853·2 m. s.			438·1 m. s.	

182. Here the two measured velocities of round 9 at station *A* differ by so much as 20·2 m.s., or 66 f.s.; those of round 10, at station *B* differ 19·4 m.s., or 64 f.s.; and other rounds differ 10·0, 9·3, 5·0 4·0 and 3·9 m.s. But that is not the worst, for there was only one solitary unchecked velocity measured at station *C*, and that was treated as a perfectly satisfactory mean velocity at *C* for all the four rounds. The mean velocities so obtained at *A* and *C*, and at *B* and *C*, were combined to calculate a certain coefficient, which was found respectively to be 3·585 and 3·700, and these differed little from the mean value 3·66 finally adopted. But if Krupp had combined the mean velocities at *A* and *B*, he would have obtained 2·584, something very different from 3·66 the value of the constant adopted.

[1] Ballistic Machines, p. 13.

183. Round 27 of Krupp's "Annexe" formed a part of the above-mentioned experiment. It is in reality the mean of *five* rounds. In this case the velocities measured at each station agreed better together. Combining the mean velocities at stations A and C, and B and C, the values of the constant were found to be respectively 3·641 and 3·743. But if those at A and B had been combined in the same way the result would have been found 2·765! It is manifest that such experiments are quite unworthy of attention.

184. Thus it appears that the Report of some experiments made by my chronograph and General Tables for velocities 131—686 m.s. were published in 1879. Krupp professes to have carried out the experiments in the following year, 1880, which formed the basis of his Tables for velocities 140—700 f.s. printed in 1881. These Tables were similar to my own.

Again the Report on experiments with my chronograph, for velocities higher than 686 m.s., was published in 1880, and in the following summer, 1881, Krupp carried out experiments of the same kind (Bulletin XXX.).

185. I believe I am correct in stating that the United States did not adopt the Krupp system of guns, and they certainly have not adopted his Tables, for Captain Ingalls in his Exterior Ballistics, 1886, intended chiefly as text book for officers in U. S. Artillery School, has stated that his table was based "upon the experiments of Bashforth," p. 129.

186. The correct method of calculating the trajectories of projectiles originally given by Bernoulli is that which I have endeavoured to render practically useful for the purpose for which it was intended. If trajectories are correctly calculated by this method, we are quite certain that any error in the result arrived at is entirely due to the defects of the data made use of, and not at all to any defect in the mode of calculation.

187. In order to test the value of the coefficients of resistance in a satisfactory manner, great care must be exercised in selecting really trustworthy experiments. Random shots are of no value. Good Range Tables, where the muzzle velocity can be relied on, seem to be the best, because the ranges and times of flight for

different elevations must respectively be consistent. But the elevations given are liable to be affected by both the "jump" and the "vertical drift" which probably vary with the elevation. It seems to me also probable that the muzzle velocity may vary slightly with the elevation of the gun. A moderate wind might produce an effect upon the range, and still not affect sensibly the time of flight. In common fairness these causes of error *must* be allowed for.

188. As a test of the accuracy of coefficients of resistance for high velocities, I prefer to apply the General Tables to calculate the times of flight for ranges given by the Range Table for elevations below 4° or 5°, because such tests are not sensibly affected by the "jump" or the "vertical drift". Take the Range Table of the 4-inch B.L. gun. Weight of projectile 25 lbs.; muzzle-velocity 1900 f.s.; jump, 6 minutes.

Experimental Ranges.	1000 yards.	2000 yards.	3000 yards.
Elevation + 6′	0° 55′	2° 17′	4° 10′
Horizontal m. velocity	1899·76 f.s.	1898·49 f.s.	1894·98 f.s.
Calc. horizon. striking velocity	1443·04 f.s.	1109·03 f.s.	944·1 f.s.
Exp. time of flight	1″·80	4″·21	7″·20
Calc. time of flight	1″·814	4″·205	7″·171
Difference in time, or	+ 0″·014	− 0″·005	− 0″·029
Difference in range	− 7 yds.	+ 2 yds.	+ 9 yds.

The negative sign in the time of flight here indicates that the coefficients of resistance are too little. As the errors in time are so very minute, it is plain that my coefficients of resistance give admirable results for velocities from 1900 f.s. to 1443 f.s. to 1109 f.s. to 944 f.s., or, for all velocities between 1900 and 944 f.s. No matter at what elevation the gun be fired, so long as the *density of the air remains unaltered*, the same coefficients of resistance must still hold good for all velocities between 1900 and 944 f.s. For the case where the density of the air decreases with the height, proper corrections must be introduced by Tables XX. and XXI. Although the form of the 4-inch projectile is probably more acutely pointed than those used in my experiments, it appears that, if anything, my coefficients are a trifle *too little.*

Krupp's correction would be utterly wrong in this case. This is the gun chosen by the authorities to be used in testing my coefficients in consequence of the Krupp scare. It is also a modern gun.

189. Referring again to the Notes by Captain H. J. May, R.N., on the Method of compiling a Range Table, 1886[1], there will be found a specimen Range Table, which we have already made use of (124), for ranges up to 4000 yards of the 12-inch B.L. gun; muzzle velocity 1892 f.s.; weight of projectile 714 lbs.; jump 6 minutes. Using the horizontal muzzle velocity in the specified cases, the General Tables have been employed to calculate the time of flight as before.

Experimental Ranges.	1000 yards	2000 yards	3000 yards	4000 yards
Elevation + 6′	0° 50′	1° 44′	2° 46′	3° 56′
Horizontal muzzle velocity	1891·8 f.s.	1891·14 f.s.	1889·79 f.s.	1887·54 f.s.
Calc. hor. striking velocity	1739·15 f.s.	1593·44 f.s.	1457·74 f.s.	1332·10 f.s.
Exp. time of flight	1″·66	3″·47	5″·44	7″·61
Calc. time of flight	1″·654	3″·457	5″·428	7″·591
Difference in time, or	− 0″·006	− 0″·013	− 0″·012	− 0″·019
Difference in range	+ 4 yds.	+ 7 yds.	+ 6 yds.	+ 8 yds.

190. Here it is manifest that my coefficients give most admirable results for velocity 1892 f.s. to 1739 f.s. to 1593 f.s. to 1458 f.s. and to 1332 f.s. or for all velocities between 1892 and 1332 f.s. And that will hold true for any elevation whatever, so long as the density of the air remains unaltered. The 12-inch B.L. gun is, I believe, a modern gun. The only way to test my coefficients of resistance for *low* velocities is by calculating trajectories. This has been done with great success for one gun (122). In the above two examples the error in range has been found by calculating how far the shot moving with its corresponding velocity would travel in the error of time.

191. The conclusion I arrive at is, that my coefficients of resistance are perfectly satisfactory, and might be used with great advantage in testing all the new heavy guns. I would measure

[1] Proceedings of the R. A. Inst. xiv. p. 356.

the muzzle velocity and time of flight for say an elevation of about 4° by my chronograph. I would also take two or more measures of the muzzle velocity by the best chronoscopes in the service to secure a reliable muzzle velocity. I would then calculate by the General Tables, as above, the time of flight over the given range. If the time of flight of the experimental projectile was then divided by the calculated time of flight over the same range, the result, as it was $<$ or >1, would show whether, and to what extent, the experimental projectile was superior or inferior in steadiness to the theoretical projectile. In this way the General Tables might be used as a standard of reference in the trial of new guns, and in process of time it would be found how far calculation might take the place of experiment. This is a matter of great practical importance, if, as I see it stated, a 110-ton gun can only fire 95 rounds, a 67-ton gun only 127 rounds, and a 45-ton gun only 150 rounds before they become respectively unserviceable.

192. I have given in Tables I.—IV. the coefficients of resistance to both spherical and ogival-headed projectiles finally adopted after a most careful re-examination of 502 rounds. In arriving at my conclusion I have had no theory to support and no interest to promote. I have been simply searching for the truth, and I have not been able to discover any satisfactory reason for changing my coefficients. But if any one should still be desirous of making a reduction of x per cent. in using the General Tables, or in calculating an arc of a trajectory, he has only to substitute $\frac{d^2}{w} \cdot \frac{100-x}{100}$ for $\frac{d^2}{w}$. If $x = 100$ he will come to the case of no resistance, and if $x > 100$ he will have an accelerating force, and all the tables may still be used as directed.

Titles in full of some Reports, &c., referred to.

(1) *Reports on Experiments made with the Bashforth Chronograph, to determine the Resistance of the Air to the Motion of Projectiles*, 1865—1870. 84/B/1941. W. Clowes & Son; Harrison & Sons; &c., &c.

(2) *Tables of Remaining Velocity, Time of Flight and Energy of various Projectiles, calculated from the Results of Experiments made with the Bashforth Chronograph*, 1865—1870. London, 1871.

(3) *A Mathematical Treatise on the Motion of Projectiles, founded chiefly on the Results of Experiments made with the Bashforth Chronograph.* London, 1873.

(4) *Supplement to the above.* London, 1881.

(5) *Report on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Elongated Projectiles.* (Part II.) 1878—79. 84/B/2853. Printed for Her Majesty's Stationery Office, 1879.

(6) Official Copy. 84/B/2909. *Final Report on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Elongated Projectiles*, 1878—80. W. Clowes & Son; Harrison & Sons; &c., &c.

I.

Coefficients for the Newtonian Law of the Resistance of the Air to Spherical Projectiles. ($\omega = 534·22$ grains.) See p 71

v f.s.	k_v	$\frac{k_v}{g}$	v f.s.	k_v	$\frac{k_v}{g}$	v f.s.	k_v	$\frac{k_v}{g}$
840	118·3	3·675	1330	194·9	6·055	1820	205·8	6·393
850	119·7	3·718	1340	195·6	6·076	1830	205·8	6·393
860	121·1	3·762	1350	196·2	6·095	1840	205·9	6·396
870	122·5	3·805	1360	196·8	6·114	1850	206·1	6·402
880	123·9	3·849	1370	197·4	6·132	1860	206·1	6·402
890	125·3	3·892	1380	197·9	6·148	1870	206·2	6·406
900	126·7	3·936	1390	198·4	6·163	1880	206·4	6·412
910	128·1	3·979	1400	198·9	6·179	1890	206·6	6·418
920	129·5	4·023	1410	199·4	6·194	1900	206·9	6·427
930	130·9	4·066	1420	199·9	6·210	1910	207·2	6·437
940	132·4	4·113	1430	200·4	6·225	1920	207·6	6·449
950	133·8	4·156	1440	200·9	6·241	1930	207·9	6·458
960	135·2	4·200	1450	201·3	6·253	1940	208·2	6·468
970	136·8	4·250	1460	201·6	6·263	1950	208·4	6·474
980	138·4	4·299	1470	202·0	6·275	1960	208·7	6·483
990	140·1	4·352	1480	202·3	6·284	1970	209·0	6·493
1000	142·0	4·411	1490	202·7	6·297	1980	209·3	6·502
1010	144·2	4·480	1500	203·0	6·306	1990	209·5	6·508
1020	146·9	4·563	1510	203·3	6·315	2000	209·8	6·517
1030	150·0	4·660	1520	203·5	6·322	2010	210·0	6·524
1040	153·3	4·762	1530	203·8	6·331	2020	210·3	6·533
1050	156·5	4·862	1540	204·1	6·340	2030	210·4	6·536
1060	159·5	4·955	1550	204·3	6·347	2040	210·5	6·539
1070	162·3	5·042	1560	204·5	6·353	2050	210·5	6·539
1080	164·9	5·123	1570	204·7	6·359	2060	210·5	6·539
1090	167·3	5·197	1580	204·9	6·365	2070	210·4	6·536
1100	169·6	5·269	1590	205·1	6·371	2080	210·3	6·533
1110	171·7	5·334	1600	205·3	6·378	2090	210·1	6·527
1120	173·7	5·396	1610	205·4	6·381	2100	209·8	6·517
1130	175·6	5·455	1620	205·6	6·387	2110	209·6	5·511
1140	177·5	5·514	1630	205·7	6·390	2120	209·3	6·502
1150	179·3	5·570	1640	205·8	6·393	2130	209·1	6·496
1160	181·0	5·623	1650	205·9	6·396	2140	208·8	6·486
1170	182·6	5·672	1660	206·0	6·399	2150	208·6	6·480
1180	184·1	5·719	1670	206·1	6·402	2160	208·4	6·474
1190	185·4	5·759	1680	206·1	6·402	2170	208·2	6·468
1200	186·6	5·797	1690	206·2	6·406	2180	208·0	6·461
1210	187·7	5·831	1700	206·2	6·406	2190	207·9	6·458
1220	188·6	5·859	1710	206·2	6·406	2200	207·7	6·452
1230	189·4	5·884	1720	206·2	6·406	2210	207·5	6·446
1240	190·2	5·909	1730	206·2	6·406	2220	207·3	6·440
1250	190·9	5·930	1740	206·2	6·406	2230	207·2	6·437
1260	191·5	5·949	1750	206·1	6·402	2240	207·0	6·430
1270	192·1	5·968	1760	206·1	6·402	2250	206·8	6·424
1280	192·6	5·983	1770	206·0	6·399	2260	206·6	6·418
1290	193·0	5·996	1780	205·9	6·396	2270	206·4	6·412
1300	193·3	6·005	1790	205·9	6·396	2280	206·1	6·402
1310	193·7	6·017	1800	205·9	6·396			
1320	194·3	6·036	1810	205·9	6·396			

II.

Approximate Law of the Resistance of the Air to the motion of Spherical Projectiles. ($\omega = 534{\cdot}22$ grains.)

$v > 1300$ *f. s.*, $f \propto v^2$, $k = 205{\cdot}3$, $\frac{k}{g} = 6{\cdot}3776$, $\log \frac{k}{g} = 0{\cdot}80466$,

$v < 1300 > 1100$ *f. s.*, $f \propto v^3$, $K = 153{\cdot}8$, $\frac{K}{g} = 4{\cdot}7778$, $\log \frac{K}{g} = 0{\cdot}67923$,

$v < 1100 > 1000$ *f. s.*, $f \propto v^4$, $h = 141{\cdot}6$, $\frac{h}{g} = 4{\cdot}3988$, $\log \frac{h}{g} = 0{\cdot}64333$,

$v < 1000 > 840$,, $f \propto v^3$, $K = 140{\cdot}7$, $\frac{K}{g} = 4{\cdot}3708$, $\log \frac{K}{g} = 0{\cdot}64056$,

$v < 840$,, $f \propto v^2$, $k = 118{\cdot}3$, $\frac{k}{g} = 3{\cdot}6749$, $\log \frac{k}{g} = 0{\cdot}56525$.

III.

Coefficients for the Newtonian Law of the Resistance of the Air to Ogival-headed Projectiles. ($\omega = 534{\cdot}22$ grains.)

v *f. s.*	k_v	$\frac{k_v}{g}$	v *f. s.*	k_v	$\frac{k_v}{g}$	v *f. s.*	k_v	$\frac{k_v}{g}$
100	60·5	1·879	1110	120·3	3·737	1430	147·9	4·594
to	,,	,,	1120	122·3	3·799	1440	148·0	4·598
810	60·5	1·879	1130	123·9	3·849	1450	148·1	4·601
820	60·6	1·883	1140	125·0	3·883	1460	148·0	4·598
830	61·1	1·898	1150	126·0	3·914	1470	148·0	4·598
840	61·8	1·920	1160	127·1	3·948	1480	148·0	4·598
850	62·6	1·945	1170	128·2	3·983	1490	147·8	4·591
860	63·3	1·966	1180	129·3	4·017	1500	147·6	4·585
870	64·0	1·988	1190	130·4	4·051	1510	147·6	4·585
880	64·8	2·013	1200	131·5	4·085	1520	147·3	4·576
890	65·5	2·035	1210	132·6	4·119	1530	147·1	4·570
900	66·2	2·057	1220	133·7	4·153	1540	146·8	4·560
910	67·0	2·081	1230	134·8	4·188	1550	146·5	4·551
920	67·7	2·103	1240	135·9	4·222	1560	146·2	4·542
930	68·4	2·125	1250	137·0	4·256	1570	145·9	4·532
940	69·2	2·150	1260	138·1	4·290	1580	145·6	4·523
950	69·9	2·171	1270	139·2	4·324	1590	145·2	4·511
960	70·7	2·196	1280	140·3	4·358	1600	144·9	4·501
970	71·4	2·218	1290	141·4	4·393	1610	144·6	4·492
980	72·1	2·240	1300	142·2	4·417	1620	144·4	4·486
990	72·9	2·265	1310	142·9	4·439	1630	144·2	4·480
1000	73·6	2·286	1320	143·6	4·461	1640	143·9	4·470
1010	74·5	2·314	1330	144·3	4·483	1650	143·6	4·461
1020	76·1	2·364	1340	144·9	4·501	1660	143·3	4·452
1030	78·9	2·451	1350	145·4	4·517	1670	143·0	4·442
1040	84·0	2·609	1360	145·8	4·529	1680	142·6	4·430
1050	91·7	2·849	1370	146·3	4·545	1690	142·3	4·421
1060	99·6	3·094	1380	146·6	4·554	1700	142·0	4·411
1070	105·6	3·281	1390	147·1	4·570	1710	141·6	4·399
1080	110·2	3·423	1400	147·3	4·576	1720	141·3	4·389
1090	114·3	3·551	1410	147·5	4·582	1730	141·0	4·380
1100	117·6	3·653	1420	147·7	4·588	1740	140·7	4·371

III. (*continued*).

v f.s.	k_v	$\frac{k_v}{g}$	v f.s.	k_v	$\frac{k_v}{g}$	v f.s.	k_v	$\frac{k_v}{g}$
1750	140·5	4·365	2100	140·7	4·371	2450	134·1	4·166
1760	140·3	4·358	2110	141·2	4·386	2460	133·6	4·150
1770	140·1	4·352	2120	141·6	4·399	2470	133·2	4·138
1780	139·9	4·346	2130	142·0	4·411	2480	132·9	4·129
1790	139·6	4·337	2140	142·5	4·427	2490	132·5	4·116
1800	139·3	4·327	2150	143·0	4·442	2500	132·2	4·107
1810	139·0	4·318	2160	143·5	4·458	2510	132·3	4·110
1820	138·8	4·312	2170	143·9	4·470	2520	132·5	4·116
1830	138·6	4·306	2180	144·2	4·480	2530	132·4	4·113
1840	138·4	4·299	2190	144·5	4·489	2540	132·5	4·116
1850	138·3	4·296	2200	144·8	4·498	2550	132·6	4·119
1860	138·2	4·293	2210	145·0	4·504	2560	132·8	4·125
1870	138·0	4·287	2220	145·1	4·507	2570	133·1	4·135
1880	137·8	4·281	2230	145·2	4·511	2580	133·4	4·144
1890	137·5	4·271	2240	145·3	4·514	2590	133·7	4·153
1900	137·2	4·262	2250	145·3	4·514	2600	133·9	4·160
1910	136·9	4·253	2260	145·1	4·507	2610	134·2	4·169
1920	136·7	4·247	2270	144·6	4·492	2620	134·6	4·181
1930	136·6	4·243	2280	144·1	4·476	2630	135·2	4·200
1940	136·6	4·243	2290	143·6	4·461	2640	135·7	4·215
1950	136·5	4·240	2300	143·1	4·445	2650	136·3	4·234
1960	136·4	4·237	2310	142·5	4·427	2660	136·8	4·250
1970	136·5	4·240	2320	142·0	4·411	2670	137·3	4·265
1980	136·6	4·243	2330	141·4	4·393	2680	137·7	4·278
1990	136·8	4·250	2340	140·9	4·377	2690	138·1	4·290
2000	137·0	4·256	2350	140·2	4·355	2700	138·5	4·302
2010	137·2	4·262	2360	139·5	4·334	2710	139·0	4·318
2020	137·5	4·271	2370	138·9	4·315	2720	139·4	4·330
2030	137·8	4·281	2380	138·2	4·293	2730	139·8	4·343
2040	138·1	4·290	2390	137·5	4·271	2740	140·3	4·358
2050	138·4	4·299	2400	136·8	4·250	2750	140·8	4·374
2060	138·8	4·312	2410	136·2	4·231	2760	141·4	4·393
2070	139·2	4·327	2420	135·6	4·212	2770	141·9	4·408
2080	139·6	4·337	2430	135·0	4·194	2780	142·4	4·424
2090	140·1	4·352	2440	134·5	4·178			

IV.

Approximate Law of the Resistance of the Air to the motion of Ogival-headed Projectiles. ($\omega = 534{\cdot}22$ grains.)

$v > 1300$ *f.s.*, $f \propto v^2$, $k = 141{\cdot}2$, $\frac{k}{g} = 4{\cdot}3864$, $\log \frac{k}{g} = 0{\cdot}64211$,

$v < 1300 > 1100$ *f.s.*, $f \propto v^8$, $K = 109{\cdot}1$, $\frac{K}{g} = 3{\cdot}3891$, $\log \frac{K}{g} = 0{\cdot}53009$,

$v < 1100 > 1000$ *f.s.*, $f \propto v^6$, $L = 77{\cdot}0$, $\frac{L}{g} = 2{\cdot}3920$, $\log \frac{L}{g} = 0{\cdot}37876$,

$v < 1000 > 820$ *f.s.*, $f \propto v^3$, $K = 73{\cdot}6$, $\frac{K}{g} = 2{\cdot}2864$, $\log \frac{K}{g} = 0{\cdot}35915$,

$v < 820$ *f.s.*, $f \propto v^2$, $k = 60{\cdot}5$, $\frac{k}{g} = 1{\cdot}8794$, $\log \frac{k}{g} = 0{\cdot}27402$

V.

Coefficients for the Newtonian Law of Resistance of the Air to Hemispherical-headed Projectiles. ($\omega = 534{\cdot}22$ grains.)

v f.s.	k_v	$\frac{k_v}{g}$	κ_1	v f.s.	k_v	$\frac{k_v}{g}$	κ_1	v f.s.	k_v	$\frac{k_v}{g}$	κ_1
1100	146·3	4·54	1·24	1670	192·0	5·97	1·34	1780	194·0	6·03	1·39
1110	147·6	4·59	1·23	1680	192·7	5·99	1·35	1790	193·3	6·01	1·38
1120	149·0	4·63	1·22	1690	193·3	6·01	1·36	1800	192·6	5·98	1·38
1130	150·3	4·67	1·21	1700	193·8	6·02	1·37	1810	191·9	5·96	1·38
1140	151·6	4·71	1·21	1710	194·3	6·03	1·37	1820	190·9	5·93	1·38
1150	153·0	4·75	1·21	1720	194·7	6·05	1·38	1830	190·0	5·90	1·37
1160	154·3	4·79	1·21	1730	195·0	6·06	1·38	1840	189·0	5·87	1·37
......	......	......	......	1740	195·1	6·06	1·39	1850	188·0	5·84	1·36
1640	189·6	5·89	1·32	1750	195·0	6·06	1·39	1860	187·1	5·81	1·35
1650	190·4	5·92	1·33	1760	194·8	6·05	1·39	1870	186·3	5·79	1·35
1660	191·2	5·94	1·33	1770	194·5	6·04	1·39				

VI.

Coefficients for the Newtonian Law of Resistance of the Air to Flat-headed Projectiles. ($\omega = 534{\cdot}22$ grains.)

v f.s.	k_v	$\frac{k_v}{g}$	κ_2	v f.s.	k_v	$\frac{k_v}{g}$	κ_2	v f.s.	k_v	$\frac{k_v}{g}$	κ_2
1530	266·7	8·28	1·81	1650	286·4	8·90	2·00	1760	301·8	9·38	2·15
1540	268·6	8·34	1·83	1660	288·0	8·95	2·01	1770	303·0	9·41	2·16
1550	270·3	8·40	1·85	1670	289·4	8·99	2·02	1780	304·2	9·44	2·17
1560	272·2	8·46	1·86	1680	291·0	9·04	2·04	1790	305·2	9·48	2·19
1570	274·0	8·51	1·88	1690	292·4	9·08	2·05	1800	306·0	9·51	2·20
1580	275·6	8·56	1·89	1700	293·9	9·13	2·07	1810	306·8	9·53	2·21
1590	277·1	8·61	1·91	1710	295·3	9·17	2·09	1820	307·4	9·55	2·22
1600	278·7	8·66	1·92	1720	296·9	9·22	2·10	1830	308·0	9·57	2·22
1610	280·3	8·71	1·94	1730	298·3	9·27	2·12	1840	308·4	9·58	2·23
1620	281·9	8·76	1·95	1740	299·5	9·30	2·13	1850	308·6	9·59	2·23
1630	283·5	8·81	1·97	1750	300·6	9·34	2·14	1860	308·6	9·59	2·23
1640	284·9	8·85	1·98								

VII.

$$Q_\phi = \sec\phi\tan\phi + \log_e \tan\left(\frac{\pi}{4}+\frac{\phi}{2}\right).$$

ϕ	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Δ
											+
0°	0·0 0000	0349	0698	1047	1396	1745	2095	2444	2793	3142	349
1	0·0 3491	3840	4190	4539	4888	5238	5587	5937	6286	6636	350
2	0·0 6986	7335	7685	8035	8385	8735	9085	9435	9786	*0136	350
3	0·1 0486	0837	1188	1538	1889	2240	2591	2942	3294	3645	351
4	0·1 3997	4348	4700	5052	5404	5757	6109	6462	6814	7167	352
5	0·1 7520	7873	8227	8580	8934	9288	9642	9996	*0350	*0705	354
6	0·2 1059	1414	1770	2125	2481	2836	3192	3549	3905	4262	356
7	0·2 4618	4976	5332	5691	6048	6406	6765	7123	7482	7841	358
8	0·2 8200	8560	8920	9280	9640	*0001	*0362	*0723	*1085	*1447	361
9	0·3 1809	2171	2534	2897	3260	3624	3988	4352	4717	5082	364
10	0·3 5447	5813	6179	6545	6912	7279	7646	8014	8382	8751	367
11	0·3 9120	9489	9858	*0228	*0599	*0969	*1341	*1712	*2084	*2457	371
12	0·4 2829	3202	3576	3950	4325	4700	5075	5451	5827	6203	375
13	0·4 6581	6958	7336	7715	8094	8473	8853	9233	9614	9996	379
14	0·5 0378	0760	1143	1526	1910	2294	2679	3065	3451	3837	384
15	0·5 4224	4612	5000	5389	5778	6168	6558	6949	7341	7733	390
16	0·5 8126	8519	8913	9307	9702	*0098	*0494	*0891	*1289	*1687	396
17	0·6 2086	2485	2885	3286	3687	4090	4492	4896	5300	5704	402
18	0·6 6110	6516	6923	7330	7739	8148	8557	8968	9379	9791	409
19	0·7 0203	0616	1030	1445	1861	2277	2694	3112	3531	3950	416
20	0·7 4371	4792	5214	5636	6060	6484	6909	7335	7762	8190	424
21	0·7 8619	9048	9478	9910	*0342	*0774	*1208	*1643	*2079	*2515	433
22	0·8 2953	3391	3830	4270	4712	5154	5597	6041	6486	6932	442
23	0·8 7380	7828	8277	8727	9178	9630	*0083	*0537	*0992	*1449	452
24	0·9 1906	2364	2824	3284	3746	4209	4672	5137	5603	6071	463
25	0·9 6539	7008	7479	7951	8424	8898	9373	9850	*0327	*0806	474
26	1·0 1286	1768	2250	2734	3219	3706	4193	4682	5173	5664	486
27	1·0 6157	6651	7147	7643	8141	8641	9142	9644	*0148	*0653	500
28	1·1 1159	1667	2176	2687	3199	3712	4227	4744	5262	5781	514
29	1·1 6302	6825	7349	7874	8402	8930	9460	9992	*0526	*1061	529
30	1·2 1597	2136	2675	3217	3760	4305	4851	5400	5950	6501	545
31	1·2 7055	7610	8167	8725	9286	9848	*0412	*0978	*1546	*2115	562
32	1·3 2687	3260	3835	4412	4991	5572	6155	6739	7326	7915	581
33	1·3 8506	9098	9693	*0290	*0889	*1490	*2093	*2698	*3305	*3915	601
34	1·4 4526	5140	5756	6374	6994	7617	8241	8868	9498	*0129	623
35	1·5 0763	1399	2038	2679	3322	3968	4616	5267	5920	6575	646
36	1·5 7233	7894	8557	9222	9890	*0561	*1234	*1910	*2589	*3270	671
37	1·6 3954	4641	5330	6022	6717	7414	8115	8818	9524	*0233	698
38	1·7 0945	1660	2378	3099	3823	4549	5279	6012	6748	7487	727
39	1·7 8229	8974	9722	*0474	*1229	*1987	*2749	*3513	*4281	*5053	758
40	1·8 5828	6606	7388	8173	8961	9753	*0549	*1348	*2151	*2958	792
41	1·9 3768	4582	5399	6221	7046	7875	8708	9544	*0385	*1229	829

VII. $Q_\phi = \sec\phi \tan\phi + \log_e \tan\left(\frac{\pi}{4} + \frac{\phi}{2}\right)$ *(continued)*.

ϕ	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Δ
											+
42°	2·0 2078	2931	3787	4648	5513	6382	7255	8132	9014	9899	869
43	2·1 0789	1684	2583	3486	4394	5306	6223	7145	8071	9001	912
44	2·1 9937	*0877	*1822	*2772	*3726	*4686	*5650	*6620	*7594	*8574	960
45	2· 2956	3055	3154	3254	3355	3456	3558	3660	3763	3866	101
46	2· 3970	4074	4179	4285	4391	4498	4605	4713	4821	4931	107
47	2· 5040	5151	5262	5373	5485	5598	5712	5826	5941	6056	113
48	2· 6173	6289	6407	6525	6644	6764	6884	7005	7127	7249	120
49	2· 7373	7497	7621	7747	7873	8000	8128	8257	8386	8516	127
50	2· 8647	8779	8912	9045	9180	9315	9451	9588	9726	9864	135
51	3· 0004	0144	0286	0428	0571	0716	0861	1007	1154	1302	144
52	3· 1451	1601	1753	1905	2058	2212	2367	2524	2681	2839	154
53	3· 2999	3160	3322	3485	3649	3814	3980	4148	4317	4487	165
54	3· 4658	4831	5004	5179	5356	5533	5712	5893	6074	6257	178
55	3· 6441	6627	6814	7[illegible]03	7193	7384	7577	7771	7967	8164	192
56	3· 8363	8563	8765	8969	9174	9381	9589	9799	*0011	*0225	207
57	4· 0440	0657	0876	1096	1318	1542	1768	1996	2226	2458	224
58	4· 2691	2927	3164	3404	3645	3889	4135	4383	4633	4885	244
59	4· 5139	5396	5655	5916	6180	6445	6714	6984	7257	7533	266
60	4· 7811	8091	8374	8660	8948	9239	9533	9829	*0129	*0431	291
61	5· 0736	1043	1354	1668	1984	2304	2627	2953	3282	3615	320
62	5· 3950	4289	4632	4978	5327	5680	6036	6396	6760	7127	353
63	5· 7498	7873	8252	8635	9022	9412	9807	0207	0610	1018	391
64	6· 1430	1847	2268	2693	3124	3559	3999	4444	4893	5348	435
65	6· 5808	6273	6743	7219	7700	8187	8679	9177	9681	0191	487
66	7· 0706	1228	1756	2291	2831	3379	3932	4493	5061	5635	548
67	7· 6217	6805	7402	8005	8616	9235	9862	*0497	*1140	*1791	620
68	8· 2451	3119	3796	4483	5178	5882	6596	7319	8052	8796	705
69	8· 9549	*0312	*1087	*1872	*2667	*3475	*4293	*5123	*5965	*6819	808
70	9· 7685	8564	9455	*0360	*1278	*2210	*3155	*4115	*5088	*6078	933
71	10· 7082	8101	9136	*0187	*1254	*2338	*3440	*4558	*5695	*6850	1085
72	11· 8023	9216	0428	1660	2912	4185	5480	6796	8134	9496	1275
73	13· 0881	2290	3723	5181	6665	8176	9713	*1278	*2871	*4493	1512
74	14· 614	14·783	14·954	15·129	15·306	15·488	15·672	15·860	16·052	16·248	181
75	16· 447	16·650	16·858	17·069	17·285	17·505	17·730	17·959	18·193	18·432	221
76	18· 676	18·925	19·180	19·440	19·705	19·977	20·254	20·538	20·828	21·124	272
77	21· 427	21·737	22·055	22·380	22·712	23·052	23·401	23·757	24·123	24·497	341
78	24· 881	25·274	25·677	26·091	26·514	26·949	27·396	27·854	28·324	28·806	436
79	29· 302	29·812	30·335	30·873	31·425	31·995	32·580	33·182	33·801	34·439	571

VIII.

Log Q_ϕ			Log Q_ϕ		
ϕ	Log Q_ϕ	Log ΔQ_ϕ	ϕ	Log Q_ϕ	Log ΔQ_ϕ
1°	8·54297	8·54337	41°	0·28728	8·91961
2	8·84420	8·54417	42	0·30552	8·94009
3	9·02063	8·54536	43	0·32385	8·96130
4	9·14603	8·54694	44	0·34230	8·98326
5	9·24353	8·54894	45	0·36089	9·00600
6	9·32345	8·55133	46	0·37966	9·02956
7	9·39126	8·55411	47	0·39864	9·05395
8	9·45026	8·55732	48	0·41785	9·07921
9	9·50255	8·56092	49	0·43732	9·10538
10	9·54958	8·56493	50	0·45708	9·13249
11	9·59239	8·56935	51	0·47718	9·16058
12	9·63174	8·57418	52	0·49764	9·18969
13	9·66821	8·57943	53	0·51850	9·21988
14	9·70224	8·58511	54	0·53981	9·25119
15	9·73420	8·59120	55	0·56159	9·28368
16	9·76437	8·59772	56	0·58391	9·31741
17	9·79299	8·60467	57	0·60681	9·35244
18	6·82027	8·61206	58	0·63034	9·38884
19	9·84636	8·61990	59	0·65456	9·42671
20	9·87140	8·62816	60	0·67952	9·46611
21	9·89553	8·63690	61	0·70531	9·50716
22	9·91883	8·64609	62	0·73199	9·54995
23	9·94141	8·65574	63	0·75965	9·59461
24	9·96334	8·66587	64	0·78838	9·64126
25	9·98470	8·67647	65	0·81828	9·69006
26	0·00555	8·68757	66	0·84946	9·74117
27	0·02594	8·69916	67	0·88205	9·79478
28	0·04595	8·71124	68	0·91620	9·85112
29	0·06559	8·72386	69	0·95206	9·91042
30	0·08492	8·73699	70	0·98983	9·97297
31	0·10399	8·75065	71	1·02971	0·03909
32	0·12283	8·76487	72	1·07197	0·10917
33	0·14147	8·77963	73	1·11688	0·18367
34	0·15995	8·79498	74	1·16478	0·26307
35	0·17830	8·81090	75	1·21609	0·34811
36	0·19654	8·82742	76	1·27129	0·43952
37	0·21472	8·84456	77	1·33097	0·53826
38	0·23286	8·86233	78	1·39587	0·64556
39	0·25098	8·88075	79	1.46690	0·76296
40	0·26911	8·89984	80	1·54526	

IX.

$\lambda = 0{\cdot}00$

ϕ	(x)	(y)	(t)	(v)
70°	27475	37743	27475	2924
69	26051	33933	26051	2790
68	24751	30630	24751	2669
67	23559	27750	23559	2559
66	22460	25223	22460	2459
65	21445	22995	21445	2366
64	20503	21019	20503	2281
63	19626	19259	19626	2203
62	18807	17686	18807	2130
61	18040	16273	18040	2063
60	17321	15000	17321	2000
59	16643	13849	16643	1942
58	16003	12805	16003	1887
57	15399	11856	15399	1836
56	14826	10990	14826	1788
55	14281	10198	14281	1743
54	13764	9472	13764	1701
53	13270	8805	13270	1662
52	12799	8191	12799	1624
51	12349	7625	12349	1589
50	11918	7101	11918	1556
49	11504	6617	11504	1524
48	11106	6167	11106	1494
47	10724	5750	10724	1466
46	10355	5362	10355	1440
45	10000	5000	10000	1414
44	9657	4663	9657	1390
43	9325	4348	9325	1367
42	9004	4054	9004	1346
41	8693	3778	8693	1325
40	8391	3520	8391	1305
39	8098	3279	8098	1287
38	7813	3052	7813	1269
37	7536	2839	7536	1252
36	7265	2639	7265	1236
35	7002	2451	7002	1221
34	6745	2275	6745	1206
33	6494	2109	6494	1192
32	6249	1952	6249	1179
31	6009	1805	6009	1167

$\lambda = 0{\cdot}00$

ϕ	(x)	(y)	(t)	(v)
30°	5774	1667	5774	1155
29	5543	1536	5543	1143
28	5317	1414	5317	1133
27	5095	1298	5095	1122
26	4877	1189	4877	1113
25	4663	1087	4663	1103
24	4452	991·1	4452	1095
23	4245	900·9	4245	1086
22	4040	816·2	4040	1079
21	3839	736·8	3839	1071
20	3640	662·4	3640	1064
19	3443	592·8	3443	1058
18	3249	527·9	3249	1051
17	3057	467·4	3057	1046
16	2867	411·1	2867	1040
15	2679	359·0	2679	1035
14	2493	310·8	2493	1031
13	2309	266·5	2309	1026
12	2126	225·9	2126	1022
11	1944	188·9	1944	1019
10	1763	155·5	1763	1015
9	1584	125·4	1584	1012
8	1405	98·8	1405	1010
7	1228	75·4	1228	1008
6	1051	55·2	1051	1006
5	875	38·3	875	1004
4	699	24·5	699	1002
3	524	13·7	524	1001
2	349	6·1	349	1001
1	175	1·5	175	1000
0	0	0	0	1000

$\lambda = 0{\cdot}01$

ϕ	(x)	(y)	(t)	(v)
70°	28628	39987	28043	3078
69	27057	35783	26547	2924
68	25635	32170	25187	2787
67	24340	29042	23945	2663

IX. (*continued*).

$\lambda = 0{\cdot}01$

ϕ	(x)	(y)	(t)	(v)
66°	23155	26315	22804	2550
65	22065	23922	21752	2448
64	21059	21812	20779	2355
63	20127	19942	19874	2269
62	19260	18275	19032	2190
61	18450	16784	18244	2117
60	17693	15445	17506	2050
59	16982	14238	16812	1988
58	16314	13147	16158	1929
57	15683	12156	15540	1874
56	15086	11255	14955	1824
55	14521	10432	14401	1776
54	13984	9679	13874	1732
53	13473	8989	13372	1690
52	12987	8355	12893	1650
51	12522	7770	12436	1613
50	12078	7231	11998	1579
49	11652	6732	11578	1546
48	11243	6271	11175	1514
47	10851	5842	10787	1485
46	10473	5444	10414	1457
45	10109	5074	10055	1431
44	9758	4729	9708	1406
43	9419	4407	9373	1382
42	9091	4107	9048	1359
41	8774	3826	8734	1338
40	8466	3563	8429	1318

$\lambda = 0{\cdot}02$

ϕ	(x)	(y)	(t)	(v)
70°	29943	42590	28669	3260
69	28191	37901	27089	3080
68	26621	33913	25661	2921
67	25204	30489	24361	2780
66	23916	27527	23172	2653
65	22741	24946	22079	2539
64	21661	22682	21071	2436

$\lambda = 0{\cdot}02$

ϕ	(x)	(y)	(t)	(v)
63°	20666	20685	20137	2341
62	19744	18914	19268	2255
61	18888	17336	18458	2176
60	18089	15924	17699	2103
59	17342	14655	16988	2036
58	16641	13511	16318	1973
57	15982	12476	15687	1915
56	15360	11535	15090	1861
55	14771	10679	14524	1811
54	14214	9898	13987	1764
53	13685	9183	13476	1719
52	13182	8526	12989	1678
51	12702	7923	12524	1639
50	12243	7367	12079	1602
49	11805	6853	11653	1568
48	11385	6379	11245	1535
47	10982	5939	10852	1505
46	10594	5530	10474	1475
45	10222	5151	10110	1448
44	9862	4798	9759	1422
43	9516	4469	9420	1397
42	9181	4162	9092	1374
41	8857	3875	8775	1352
40	8543	3607	8467	1330

$\lambda = 0{\cdot}03$

ϕ	(x)	(y)	(t)	(v)
70°	31463	45656	29366	3477
69	29483	40356	27687	3263
68	27731	35905	26178	3077
67	26167	32125	24812	2914
66	24758	28884	23568	2770
65	23481	26081	22430	2641
64	22317	23639	21382	2526
63	21250	21498	20415	2421
62	20267	19608	19518	2327
61	19357	17932	18682	2240

IX. (*continued*).

$\lambda = 0{\cdot}03$

ϕ	(x)	(y)	(t)	(v)
60°	18512	16438	17903	2161
59	17725	15101	17172	2088
58	16988	13899	16486	2021
57	16298	12814	15839	1959
56	15648	11832	15229	1901
55	15035	10940	14652	1847
54	14455	10128	14104	1797
53	13906	9386	13584	1751
52	13385	8706	13088	1707
51	12889	8082	12615	1666
50	12416	7508	12164	1627
49	11964	6979	11731	1591
48	11532	6490	11317	1557
47	11117	6038	10918	1525
46	10720	5619	10536	1494
45	10338	5230	10167	1466
44	9970	4868	9812	1438
43	9615	4532	9469	1413
42	9273	4218	9138	1388
41	8942	3925	8817	1365
40	8622	3652	8506	1343

$\lambda = 0{\cdot}04$

ϕ	(x)	(y)	(t)	(v)
70°	33257	49344	30152	3746
69	30981	43250	28352	3483
68	28999	38216	26747	3261
67	27252	33996	25304	3070
66	25697	30418	23997	2903
65	24300	27351	22806	2757
64	23037	24701	21715	2627
63	21886	22392	20711	2510
62	20833	20367	19782	2405
61	19863	18580	18920	2310
60	18966	16995	18116	2224
59	18134	15581	17365	2145
58	17358	14315	16661	2072

$\lambda = 0{\cdot}04$

ϕ	(x)	(y)	(t)	(v)
57°	16633	13176	15999	2005
56	15953	12148	15374	1944
55	15313	11217	14784	1886
54	14709	10370	14225	1833
53	14139	9599	13695	1784
52	13598	8894	13190	1737
51	13084	8249	12709	1694
50	12596	7656	12250	1653
49	12130	7110	11811	1615
48	11684	6606	11390	1579
47	11258	6141	10986	1546
46	10850	5711	10598	1514
45	10458	5312	10225	1484
44	10081	4941	9865	1456
43	9718	4597	9518	1429
42	9368	4276	9183	1404
41	9030	3977	8859	1380
40	8703	3698	8545	1357

$\lambda = 0{\cdot}05$

ϕ	(x)	(y)	(t)	(v)
70°	35424	53902	31056	4088
69	32747	46734	29103	3755
68	30466	40938	27381	3482
67	28489	36164	25846	3253
66	26754	32169	24466	3058
65	25212	28785	23215	2889
64	23831	25887	22074	2741
63	22583	23383	21028	2609
62	21448	21202	20064	2493
61	20409	19288	19171	2388
60	19454	17599	18342	2293
59	18571	16099	17569	2207
58	17752	14762	16845	2128
57	16988	13563	16165	2056
56	16275	12485	15526	1989
55	15605	11511	14922	1928

IX. (*continued*).

$\lambda = 0·05$					$\lambda = 0·05$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
54°	14976	10628	14351	1871	15°	2716	365·6	2698	1050
53	14382	9825	13810	1818	14	2525	316·1	2509	1044
52	13821	9093	13296	1769	13	2336	270·7	2322	1038
51	13288	8424	12806	1724	12	2148	229·2	2137	1033
50	12783	7811	12339	1681	11	1963	191·4	1953	1029
49	12302	7247	11893	1641	10	1779	157·3	1771	1025
48	11843	6728	11466	1603	9	1597	126·8	1590	1021
47	11404	6249	11056	1567	8	1415	99·7	1410	1017
46	10984	5807	10663	1534	7	1235	76·0	1232	1014
45	10582	5397	10285	1503	6	1057	55·6	1054	1011
44	10195	5017	9921	1474	5	879	38·5	877	1008
43	9823	4664	9570	1446	4	702	24·6	700	1006
42	9465	4336	9231	1419	3	526	13·8	525	1004
41	9120	4031	8903	1394	2	350	6·1	349	1002
40	8786	3746	8585	1370	+1	175	1·5	175	1001
39	8464	3480	8278	1348	0	0	0	0	1000
38	8152	3232	7980	1327	−1	174	1·5	175	999
37	7849	2999	7690	1307	2	348	6·1	349	999
36	7555	2782	7408	1288	3	523	13·7	523	999
35	7270	2578	7134	1270	4	697	24·3	698	999
34	6993	2388	6867	1252	5	871	38·1	873	1000
33	6722	2209	6607	1236	6	1045	54·9	1048	1000
32	6459	2041	6353	1220	7	1220	74·8	1224	1001
31	6203	1884	6104	1206	8	1395	97·8	1400	1003
30	5952	1736	5862	1192	9	1571	124·1	1578	1004
29	5707	1597	5624	1178	10	1748	153·7	1755	1007
28	5467	1467	5391	1165	11	1925	186·5	1934	1009
27	5233	1345	5163	1152	12	2103	222·7	2114	1012
26	5003	1231	4939	1142	13	2282	262·5	2295	1015
25	4777	1123	4720	1131	14	2462	305·7	2478	1018
24	4556	1022	4504	1121	15	2644	352·6	2662	1022
23	4339	927·7	4291	1111	16	2827	403·3	2847	1026
22	4125	839·2	4082	1102	17	3011	457·9	3034	1030
21	3915	756·5	3877	1093	18	3197	516·6	3223	1035
20	3708	679·1	3674	1085	19	3384	579·4	3414	1040
19	3504	606·9	3474	1077	20	3574	646·5	3607	1045
18	3303	539·7	3276	1069	21	3766	718·2	3802	1051
17	3105	477·2	3081	1062	22	3959	794·5	4000	1057
16	2910	419·2	2888	1056	23	4156	875·8	4200	1063
					24	4354	962·1	4403	1070

IX. (*continued*).

$\lambda = 0{\cdot}05$

ϕ	(x)	(y)	(t)	(v)
25°	4555	1054	4609	1078
26	4760	1151	4818	1085
27	4967	1255	5030	1094
28	5177	1364	5247	1102
29	5391	1480	5466	1111
30	5609	1603	5690	1121
31	5830	1734	5918	1131
32	6055	1872	6151	1142
33	6285	2018	6388	1153
34	6520	2173	6631	1165
35	6759	2338	6879	1177
36	7003	2512	7133	1190
37	7253	2697	7392	1204
38	7509	2894	7659	1218
39	7771	3102	7932	1233
40	8040	3324	8213	1249
41	8316	3559	8501	1265
42	8599	3810	8798	1282
43	8890	4077	9104	1300
44	9189	4361	9419	1320
45	9498	4664	9744	1340
46	9816	4988	10080	1360
47	10144	5334	10428	1382
48	10483	5704	10788	1405
49	10834	6100	11161	1429
50	11197	6525	11549	1455
51	11573	6982	11952	1482
52	11963	7473	12371	1510
53	12369	8002	12809	1540
54	12791	8572	13265	1571
55	13231	9188	13742	1603
56	13689	9855	14241	1638
57	14168	10579	14765	1675
58	14668	11365	15315	1713
59	15193	12221	15894	1754
60	15743	13155	16505	1797
61	16320	14176	17150	1842
62	16928	15296	17833	1891
63	17568	16526	18557	1941

$\lambda = 0{\cdot}05$

ϕ	(x)	(y)	(t)	(v)
64°	18244	17883	19327	1995
65	18959	19382	20147	2052
66	19716	21043	21024	2113
67	20519	22891	21963	2178
68	21373	24954	22972	2246
69	22283	27263	24059	2319
70	23253	29859	25235	2397
71	24289	32789	26509	2479
72	25400	36109	27897	2566
73	26591	39889	29414	2659
74	27871	44213	31079	2758
75	29249	49185	32915	2862
76	30734	54932	34950	2973
77	32336	61614	37217	3089
78	34068	69431	39758	3211
79	35939	78639	42627	3338
80	37961	89563	45890	3470

$\lambda = 0{\cdot}06$

ϕ	(x)	(y)	(t)	(v)
70°	38133	59745	32116	4545
69	34883	51042	29965	4102
68	32196	44214	28096	3755
67	29920	38715	26449	3474
66	27956	34196	24981	3240
65	26236	30420	23659	3042
64	24713	27223	22461	2871
63	23349	24488	21368	2722
62	22119	22123	20364	2590
61	21001	20064	19438	2473
60	19979	18256	18581	2368
59	19040	16661	17783	2274
58	18171	15243	17038	2188
57	17366	13978	16340	2110
56	16615	12844	15684	2038
55	15914	11823	15066	1972

IX. (*continued*).

$\lambda = 0{\cdot}06$

ϕ	(x)	(y)	(t)	(v)
54°	15256	10900	14482	1912
53	14637	10064	13930	1856
52	14053	9302	13405	1803
51	13501	8608	12906	1755
50	12977	7973	12431	1710
49	12480	7390	11977	1667
48	12006	6855	11543	1628
47	11554	6362	11128	1591
46	11122	5906	10729	1556
45	10709	5486	10346	1523
44	10312	5096	9977	1492
43	9931	4734	9621	1463
42	9565	4398	9278	1436
41	9212	4086	8947	1410
40	8871	3795	8626	1385

$\lambda = 0{\cdot}07$

ϕ	(x)	(y)	(t)	(v)
51°	13724	8803	13011	1788
50	13181	8144	12527	1740
49	12667	7541	12065	1695
48	12177	6988	11624	1654
47	11711	6479	11202	1615
46	11267	6011	10797	1578
45	10842	5578	10409	1544
44	10434	5178	10035	1511
43	10044	4807	9675	1481
42	9668	4463	9328	1452
41	9307	4143	8992	1425
40	8959	3846	8668	1400

$\lambda = 0{\cdot}07$

ϕ	(x)	(y)	$(t$	(v)
70°	41699	67658	33405	5200
69	37561	56575	30979	4568
68	34292	48267	28918	4105
67	31609	41785	27129	3747
66	29348	36580	25554	3460
65	27403	32310	24148	3222
64	25705	28747	22884	3022
63	24203	25732	21736	2850
62	22860	23152	20687	2700
61	21650	20922	19724	2569
60	20551	18978	18834	2452
59	19546	17272	18009	2348
58	18623	15765	17241	2254
57	17770	14426	16523	2169
56	16979	13230	15850	2091
55	16242	12157	15216	2021
54	15553	11191	14619	1955
53	14906	10317	14054	1895
52	14298	9524	13519	1839

$\lambda = 0{\cdot}08$

ϕ	(x)	(y)	(t)	(v)
70°	46794	79353	35058	6255
$69\frac{3}{4}$	45170	74922	34284	5952
$69\frac{1}{2}$	43694	70947	33555	5686
$69\frac{1}{4}$	42342	67355	32866	5450
69	41096	64087	32211	5240
$68\frac{3}{4}$	39942	61099	31589	5050
$68\frac{1}{2}$	38867	58354	30995	4877
$68\frac{1}{4}$	37863	55820	30426	4720
68	36921	53473	29882	4576
$67\frac{3}{4}$	36034	51292	29360	4442
$67\frac{1}{2}$	35197	49258	28858	4319
$67\frac{1}{4}$	34405	47358	28375	4204
67	33653	45576	27909	4097
66	30988	39442	26198	3731
65	28751	34528	24691	3439
64	26832	30503	23347	3199
63	25159	27146	22136	2997
62	23682	24306	21036	2825
61	22362	21875	20030	2676
60	21174	19773	19105	2545
59	20095	17941	18250	2429

IX. (*continued*).

$\lambda = 0{\cdot}08$

φ	(x)	(y)	(t)	(v)
58°	19109	16332	17456	2326
57	18203	14909	16716	2232
56	17366	13644	16023	2148
55	16590	12514	15373	2071
54	15866	11500	14762	2001
53	15190	10585	14184	1937
52	14555	9758	13637	1878
51	13958	9007	13118	1823
50	13394	8323	12625	1772
49	12861	7698	12155	1725
48	12355	7126	11707	1681
47	11874	6601	11278	1640
46	11416	6118	10867	1601
45	10978	5673	10473	1565
44	10560	5262	10094	1531
43	10159	4882	9730	1500
42	9775	4529	9378	1470
41	9405	4202	9039	1441
40	9049	3898	8711	1415

$\lambda = 0{\cdot}09$

φ	(x)	(y)	(t)	(v)
70°	55375	99919	37405	8411
69¾	52545	92196	36384	7718
69½	50134	85701	35453	7167
69¼	48035	80124	34594	6715
69	46180	75259	33795	6334
68¾	44520	70962	33049	6009
68½	43019	67127	32346	5726
68¼	41651	63676	31684	5477
68	40395	60547	31055	5256
67¾	39235	57694	30458	5058
67½	38159	55079	29889	4879
67¼	37155	52670	29345	4716
67	36215	50443	28824	4567
66¾	35333	48376	28324	4430
66½	34501	46452	27844	4304

$\lambda = 0{\cdot}09$

φ	(x)	(y)	(t)	(v)
66¼°	33715	44655	27382	4186
66	32970	42972	26936	4077
65	30336	37186	25301	3706
64	28131	32560	23860	3412
63	26244	28773	22574	3171
62	24601	25615	21414	2970
61	23151	22943	20360	2798
60	21857	20655	19395	2650
59	20692	18677	18506	2520
58	19635	16950	17684	2405
57	18669	15433	16919	2302
56	17781	14091	16206	2210
55	16961	12898	15538	2127
54	16199	11830	14910	2051
53	15490	10871	14319	1982
52	14827	10006	13760	1918
51	14204	9223	13230	1860
50	13618	8512	12727	1806
49	13064	7864	12249	1756
48	12541	7272	11792	1709
47	12044	6729	11356	1666
46	11571	6231	10939	1626
45	11121	5773	10539	1588
44	10691	5350	10155	1552
43	10279	4959	9786	1519
42	9885	4598	9430	1488
41	9506	4263	9087	1458
40	9142	3952	8755	1431

$\lambda = 0{\cdot}10$

φ	(x)	(y)	(t)	(v)
70°	81218	166085	42040	19221
69¾	69862	135118	40009	13684
69½	63221	117242	38466	11178
69¼	58519	104747	37181	9669
69	54884	95214	36064	8631
68¾	51926	87558	35067	7862
68½	49437	81198	34163	7262

IX. (*continued*).

λ=0·10					λ=0·10				
φ	(x)	(y)	(t)	(v)	φ	(x)	(y)	(t)	(v)
68¼°	47292	75785	33333	6776	39°	8880	3712	8476	1419
68	45409	71094	32564	6372	38	8534	3437	8162	1394
67¾	43733	66972	31846	6030	37	8201	3182	7858	1369
67½	42225	63308	31172	5734	36	7879	2943	7564	1346
67¼	40855	60021	30537	5476	35	7568	2721	7277	1325
67	39601	57049	29935	5248	34	7267	2514	6999	1304
66¾	38446	54345	29364	5044	33	6974	2320	6728	1285
66½	37377	51870	28819	4861	32	6690	2140	6464	1266
66¼	36382	49594	28299	4694	31	6414	1970	6207	1249
66	35451	47492	27801	4543	30	6146	1812	5955	1232
65¾	34579	45543	27324	4404	29	5884	1664	5710	1216
65½	33757	43730	26865	4275	28	5629	1526	5470	1202
65¼	32982	42039	26424	4157	27	5380	1396	5235	1187
65	32248	40456	25999	4047	26	5137	1275	5005	1174
64	29657	35018	24436	3673	25	4899	1162	4779	1161
63	27492	30673	23059	3379	24	4667	1056	4558	1149
62	25642	27117	21828	3139	23	4439	956·4	4340	1137
61	24033	24152	20717	2939	22	4215	863·8	4126	1126
60	22613	21641	19706	2769	21	3996	777·4	3916	1116
59	21347	19491	18780	2621	20	3781	696·9	3709	1106
58	20207	17629	17926	2493	19	3569	621·9	3505	1097
57	19172	16004	17135	2379	18	3361	552·2	3304	1088
56	18226	14575	16399	2278	17	3156	487·5	3106	1080
55	17357	13310	15711	2187	16	2954	427·7	2910	1072
54	16554	12183	15067	2105	15	2755	372·4	2717	1065
53	15808	11176	14460	2030	14	2558	321·6	2525	1058
52	15113	10270	13888	1962	13	2364	275·0	2336	1051
51	14463	9452	13347	1899	12	2172	232·5	2149	1045
50	13853	8711	12834	1842	11	1983	194·0	1963	1039
49	13278	8038	12346	1790	10	1795	159·2	1779	1034
48	12735	7424	11881	1739	9	1610	128·2	1596	1029
47	12221	6863	11438	1694	8	1426	100·7	1415	1024
46	11733	6349	11014	1651	7	1243	76·6	1235	1020
45	11269	5876	10608	1612	6	1062	56·0	1057	1016
44	10826	5441	10218	1574	5	883	38·7	879	1013
43	10403	5040	9843	1539	4	704	24·7	702	1010
42	9999	4669	9483	1506	3	527	13·8	526	1007
41	9611	4326	9135	1476	2	351	6·1	350	1004
40	9238	4007	8800	1447	+1	175	1·5	175	1002

IX. (*continued*).

$\lambda = 0\cdot10$					$\lambda = 0\cdot10$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
0	0	0	0	1000	40°	7727	3150	8050	1199
1°	174	1·5	174	998	41	7981	3367	8326	1213
2	348	6·1	349	997	42	8241	3597	8611	1227
3	521	13·6	523	996	43	8507	3841	8903	1243
4	695	24·2	697	996	44	8780	4100	9204	1259
5	867	37·8	871	995	45	9060	4375	9514	1275
6	1040	54·5	1046	995	46	9348	4668	9834	1293
7	1213	74·2	1221	995	47	9644	4980	10164	1311
8	1386	96·9	1396	996	48	9948	5312	10505	1331
9	1559	122·8	1572	997	49	10262	5667	10858	1351
10	1733	151·9	1748	998	50	10585	6046	11224	1372
11	1907	184·1	1925	999	51	10919	6450	11603	1393
12	2082	219·7	2103	1001	52	11263	6884	11997	1417
13	2257	258·5	2283	1003	53	11620	7348	12407	1441
14	2433	300·8	2463	1006	54	11988	7846	12833	1466
15	2610	346·6	2644	1008	55	12370	8382	13278	1493
16	2788	395·9	2827	1011	56	12766	8958	13742	1520
17	2967	449·0	3012	1015	57	13177	9579	14228	1549
18	3147	505·8	3198	1018	58	13604	10250	14736	1580
19	3329	566·6	3385	1022	59	14049	10975	15269	1612
20	3512	631·5	3575	1027	60	14512	11761	15829	1645
21	3697	700·6	3767	1031	61	14994	12614	16418	1680
22	3884	774·1	3961	1036	62	15497	13541	17039	1717
23	4072	852·1	4157	1042	63	16023	14552	17696	1755
24	4263	935·0	4356	1048	64	16573	15655	18390	1795
25	4455	1023	4557	1054	65	17149	16863	19127	1838
26	4650	1116	4762	1060	66	17752	18188	19909	1882
27	4848	1214	4969	1067	67	18386	19644	20743	1928
28	5048	1318	5180	1074	68	19051	21250	21634	1976
29	5251	1429	5394	1082	69	19750	23026	22587	2027
30	5457	1545	5612	1090	70	20485	24994	23611	2080
31	5666	1668	5834	1099	71	21260	27183	24713	2134
32	5878	1798	6059	1108	72	22077	29625	25903	2192
33	6095	1936	6290	1117	73	22938	32357	27192	2251
34	6314	2082	6525	1127	74	23846	35426	28595	2312
35	6538	2236	6765	1138	75	24805	38886	30127	2376
36	6767	2398	7010	1149	76	25818	42804	31806	2441
37	6999	2571	7264	1161	77	26886	47258	33657	2508
38	7237	2753	7517	1173	78	28014	52347	35708	2575
39	7479	2946	7780	1185	79	29202	58195	37994	2644
					80	30454	64955	40561	2712

IX. (*continued*).

λ = 0·11					λ = 0·12				
φ	(x)	(y)	(t)	(v)	φ	(x)	(y)	(t)	(v)
68¼°	57839	99473	35819	9888	67°	52928	84598	33410	8758
68	54069	90087	34731	8752	66¾	49912	77534	32487	7905
67¾	51047	82651	33768	7927	66½	47412	71749	31655	7256
67½	48527	76529	32897	7292	66¼	45280	66874	30894	6740
67¼	46370	71353	32099	6785	66	43424	62679	30191	6316
67	44487	66888	31362	6366	65¾	41782	59012	29536	5960
66¾	42817	62978	30675	6014	65½	40311	55766	28922	5656
66½	41319	59511	30030	5711	65¼	38981	52864	28344	5392
66¼	39962	56409	29423	5448	65	37767	50246	27797	5160
66	38723	53608	28849	5215	64¾	36652	47868	27277	4953
65¾	37583	51064	28303	5009	64½	35622	45696	26782	4768
65½	36529	48737	27784	4823	64¼	34665	43700	26310	4601
65¼	35549	46600	27287	4656	64	33772	41858	25858	4449
65	34635	44627	26813	4503	63¾	32935	40152	25424	4311
64¾	33778	42799	26357	4363	63½	32148	38565	25007	4183
64½	32971	41099	25919	4235	63¼	31406	37085	24605	4065
64¼	32211	39514	25498	4116	63	30704	35701	24218	3956
64	31492	38030	25092	4006	62	28230	30944	22795	3587
63	28954	32937	23601	3633	61	26167	27142	21537	3298
62	26837	28867	22284	3341	60	24405	24025	20411	3063
61	25029	25535	21107	3103	59	22872	21422	19392	2868
60	23456	22754	20043	2905	58	21520	19214	18462	2702
59	22070	20399	19074	2736	57	20314	17319	17608	2559
58	20833	18379	18185	2591	56	19227	15676	16818	2434
57	19718	16630	17364	2464	55	18239	14239	16086	2324
56	18707	15101	16602	2352	54	17336	12973	15403	2226
55	17783	13755	15893	2252	53	16506	11850	14762	2138
54	16932	12563	15230	2163	52	15738	10849	14160	2059
53	16147	11501	14607	2082	51	15024	9952	13593	1986
52	15417	10550	14021	2008	50	14359	9144	13057	1920
51	14737	9694	13467	1941	49	13735	8414	12550	1860
50	14100	8921	12943	1880	48	13150	7752	12067	1805
49	13501	8221	12446	1823	47	12597	7149	11607	1753
48	12938	7584	11972	1771	46	12076	6599	11169	1706
47	12406	7003	11521	1723	45	11581	6096	10750	1662
46	11901	6471	11090	1678	44	11111	5634	10348	1620
45	11422	5983	10678	1636	43	10664	5209	9963	1582
44	10967	5535	10282	1597	42	10237	4818	9593	1546
43	10532	5123	9902	1560	41	9829	4457	9237	1513
42	10116	4742	9537	1526	40	9438	4123	8893	1481
41	9719	4390	9185	1494					
40	9337	4064	8846	1464					

IX. (*continued*).

$\lambda = 0.13$

ϕ	(x)	(y)	(t)	(v)
66°	51486	78857	32101	8648
65¾	48547	72293	31226	7802
65½	46115	66923	30436	7156
65¼	44042	62400	29715	6644
65	42239	58510	29048	6225
64¾	40644	55110	28427	5873
64½	39217	52100	27844	5573
64¼	37925	49407	27296	5312
64	36747	46979	26776	5083
63¾	35665	44773	26283	4879
63½	34666	42756	25813	4697
63¼	33737	40903	25363	4533
63	32870	39192	24933	4383
62¾	32058	37607	24520	4247
62½	31294	36133	24123	4121
62¼	30574	34757	23741	4005
62	29893	33469	23372	3898
61	27491	29041	22015	3535
60	25487	25496	20814	3251
59	23774	22586	19737	3021
58	22283	20152	18761	2829
57	20967	18086	17869	2666
56	19792	16310	17048	2526
55	18733	14769	16289	2403
54	17771	13419	15583	2295
53	16890	12228	14924	2199
52	16079	11171	14306	2113
51	15329	10228	13725	2035
50	14632	9382	13176	1964
49	13981	8620	12657	1899
48	13371	7930	12165	1840
47	12798	7304	11697	1785
46	12257	6734	11250	1735
45	11746	6214	10824	1688
44	11261	5738	10416	1645
43	10801	5300	10025	1605
42	10362	4898	9650	1567
41	9943	4527	9289	1532
40	9542	4185	8941	1499

$\lambda = 0.14$

ϕ	(x)	(y)	(t)	(v)
65°	49792	73004	30811	8435
64¾	46991	67031	29988	7620
64½	44667	62130	29245	6998
64¼	42683	57993	28565	6503
64	40954	54428	27936	6097
63¾	39424	51307	27349	5756
63½	38052	48540	26798	5464
63¼	36810	46062	26279	5211
63	35676	43825	25787	4988
62¾	34634	41790	25319	4790
62½	33670	39929	24873	4612
62¼	32775	38217	24447	4452
62	31938	36636	24038	4306
61¾	31154	35170	23646	4173
61½	30417	33804	23269	4050
61¼	29721	32530	22905	3937
61	29063	31336	22554	3832
60	26739	27225	21261	3478
59	24798	23928	20114	3200
58	23137	21216	19083	2975
57	21690	18944	18148	2788
56	20412	17011	17292	2628
55	19269	15349	16503	2491
54	18239	13903	15773	2371
53	17301	12636	15093	2265
52	16443	11517	14457	2171
51	15653	10523	13860	2087
50	14921	9635	13298	2010
49	14240	8837	12768	1941
48	13604	8118	12265	1878
47	13008	7467	11787	1820
46	12447	6876	11333	1766
45	11918	6338	10899	1717
44	11417	5846	10485	1671
43	10942	5395	10088	1629
42	10491	4981	9707	1589
41	10060	4600	9341	1552
40	9649	4249	8989	1518

IX. (*continued*).

λ=0·15				
φ	(x)	(y)	(t)	(v)
64½°	55459	82861	31412	10758
64¼	51164	73902	30412	9185
64	47909	67189	29549	8139
63¾	45292	61852	28782	7379
63½	43107	57444	28087	6794
63¼	41233	53707	27449	6326
63	39595	50473	26858	5940
62¾	38140	47634	26305	5614
62½	36834	45111	25786	5335
62¼	35649	42847	25296	5091
62	34566	40799	24831	4877
61¾	33569	38933	24388	4687
61½	32646	37224	23966	4515
61¼	31787	35650	23562	4360
61	30984	34195	23174	4220
60	28220	29304	21764	3761
59	25979	25498	20533	3417
58	24104	22436	19437	3147
57	22498	19912	18451	2927
56	21096	17794	17555	2745
55	19856	15989	16734	2589
54	18748	14433	15976	2455
53	17745	13079	15273	2338
52	16833	11890	14618	2235
51	15998	10839	14004	2143
50	15227	9905	13428	2060
49	14514	9069	12884	1985
48	13849	8318	12370	1918
47	13228	7640	11883	1856
46	12646	7026	11420	1799
45	12098	6468	10979	1747
44	11580	5959	10557	1698
43	11090	5494	10154	1654
42	10625	5067	9767	1612
41	10182	4676	9396	1573
40	9760	4315	9039	1537
+	......	......	......	......
0	0	0	0	1000
−	......	......	......	......
40	7444	2996	7899	1154
41	7679	3197	8165	1166
42	7919	3409	8438	1179

λ=0·15				
φ	(x)	(y)	(t)	(v)
43°	8164	3634	8719	1192
44	8415	3872	9007	1205
45	8671	4124	9304	1220
46	8934	4392	9610	1235
47	9204	4676	9925	1250
48	9480	4977	10250	1266
49	9764	5298	10586	1283
50	10055	5639	10933	1301
51	10355	6003	11292	1320
52	10663	6390	11665	1339
53	10981	6804	12052	1359
54	11308	7247	12454	1380
55	11646	7720	12872	1402
56	11994	8227	13307	1425
57	12354	8772	13762	1449
58	12727	9356	14236	1473
59	13112	9986	14733	1499
60	13512	10664	15253	1526
61	13926	11396	15799	1554
62	14356	12187	16373	1584
63	14802	13045	16978	1614
64	15265	13975	17615	1645
65	15747	14986	18289	1679
66	16249	16087	19003	1713
67	16772	17289	19760	1748
68	17316	18605	20566	1785
69	17884	20047	21425	1823
70	18477	21632	22344	1862
71	19095	23379	23328	1903
72	19741	25310	24387	1944
73	20415	27450	25528	1987
74	21120	29828	26763	2031
75	21855	32482	28104	2075
76	22623	35453	29567	2120
77	23424	38794	31170	2166
78	24260	42567	32935	2211
79	25131	46851	34892	2256
80	26037	51746	37077	2301

IX. (*continued*).

$\lambda = 0{\cdot}16$					$\lambda = 0{\cdot}17$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
63°	45906	61547	28320	7786	62½°	49842	67590	28682	9367
62¾	43499	56847	27610	7095	62¼	46493	61188	27858	8216
62½	41472	52931	26963	6556	62	43844	56179	27132	7401
62¼	39722	49588	26367	6121	61¾	41656	52085	26476	6783
62	38185	46681	25813	5759	61½	39795	48638	25877	6295
61¾	36815	44118	25295	5453	61¼	38176	45672	25322	5897
61½	35581	41833	24806	5189	61	36746	43078	24805	5563
61¼	34459	39776	24344	4958	60¾	35465	40779	24319	5278
61	33430	37912	23906	4754	60½	34307	38722	23861	5031
60¾	32482	36209	23488	4573	60¼	33250	36863	23427	4814
60½	31602	34647	23088	4409	60	32280	35173	23013	4622
60¼	30783	33206	22706	4261	59¾	31382	33627	22619	4450
60	30016	31871	22339	4125	59½	30548	32204	22242	4295
59¾	29296	30630	21986	4002	59¼	29770	30889	21880	4154
59½	28617	29472	21645	3887	59	29040	29669	21532	4026
59¼	27976	28388	21317	3782	58	26512	25540	20261	3604
59	27368	27371	20999	3684	57	24449	22299	19145	3284
58	25215	23855	19826	3352	56	22712	19673	18147	3032
57	23408	21018	18781	3093	55	21217	17497	17245	2826
56	21857	18673	17838	2878	54	19909	15662	16422	2654
55	20502	16700	16980	2700	53	18747	14091	15665	2508
54	19301	15016	16191	2549	52	17705	12733	14965	2381
53	18225	13562	15463	2419	51	16762	11547	14313	2270
52	17253	12294	14786	2305	50	15902	10503	13704	2172
51	16367	11179	14154	2204	49	15112	9577	13132	2085
50	15554	10193	13562	2114	48	14382	8752	12593	2006
49	14804	9314	13005	2033	47	13705	8013	12084	1935
48	14108	8528	12479	1960	46	13073	7347	11602	1870
47	13460	7821	11981	1894	45	12482	6746	11144	1811
46	12854	7182	11509	1834	44	11927	6200	10707	1757
45	12285	6603	11059	1778	43	11403	5703	10290	1707
44	11750	6076	10630	1727	42	10909	5250	9892	1661
43	11243	5596	10221	1680	41	10440	4835	9510	1618
42	10764	5156	9828	1636	40	9994	4454	9143	1578
41	10309	4753	9452	1595					
40	9875	4383	9090	1557					

IX. (*continued*).

$\lambda = 0{\cdot}18$					$\lambda = 0{\cdot}19$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
61¼°	44123	55419	26650	7705	60¾°	47499	60177	26921	9115
61	41775	51154	25987	7003	60½	44326	54540	26163	7999
60¾	39804	47615	25384	6459	60¼	41815	50122	25493	7207
60½	38107	44601	24830	6023	60	39739	46508	24889	6608
60¼	36621	41986	24314	5662	59¾	37972	43462	24336	6134
60	35298	39684	23832	5357	59½	36434	40839	23824	5747
59¾	34108	37632	23378	5094	59¼	35075	38543	23346	5423
59½	33026	35787	22949	4866	59	33858	36507	22897	5146
59¼	32037	34115	22541	4664	58¾	32757	34683	22473	4906
59	31124	32589	22152	4484	58½	31752	33035	22070	4696
58¾	30279	31189	21780	4323	58¼	30828	31534	21688	4509
58½	29491	29897	21424	4177	58	29974	30161	21322	4342
58¼	28754	28701	21082	4043	57¾	29180	28896	20972	4192
58	28063	27588	20753	3922	57½	28438	27726	20636	4055
57	25657	23809	19547	3520	57¼	27743	26641	20313	3930
56	23684	20826	18484	3215	57	27089	25629	20002	3815
55	22018	18400	17532	2972	56	24806	22176	18858	3435
54	20580	16383	16670	2774	55	22923	19435	17846	3144
53	19318	14677	15880	2608	54	21327	17196	16937	2911
52	18196	13214	15154	2466	53	19945	15328	16112	2721
51	17188	11946	14480	2343	52	18730	13744	15355	2560
50	16274	10837	13852	2235	51	17648	12382	14657	2423
49	15439	9860	13264	2140	50	16673	11200	14009	2305
48	14672	8992	12712	2055	49	15788	10163	13404	2200
47	13962	8217	12191	1978	48	14979	9248	12836	2108
46	13303	7522	11698	1909	47	14234	8435	12303	2025
45	12688	6896	11231	1846	46	13545	7708	11799	1951
44	12112	6330	10786	1789	45	12904	7056	11321	1883
43	11570	5816	10362	1736	44	12305	6467	10868	1822
42	11059	5347	9957	1687	43	11743	5934	10436	1766
41	10576	4920	9569	1642	42	11215	5450	10025	1714
40	10117	4528	9197	1600	41	10716	5008	9631	1667
					40	10244	4605	9253	1623

IX. (*continued*).

$\lambda = 0{\cdot}20$					$\lambda = 0{\cdot}20$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
60°	47859	59443	26438	9557	30°	6592	1991	6165	1327
59¾	44421	53516	25667	8272	29	6290	1820	5901	1305
59½	41759	48973	24993	7390	28	5997	1661	5643	1285
59¼	39590	45308	24389	6736	27	5714	1513	5393	1265
59	37761	42249	23839	6227	26	5439	1376	5148	1246
58¾	36182	39633	23331	5816	25	5172	1249	4909	1228
58½	34794	37356	22858	5474	24	4912	1130	4675	1212
58¼	33556	35345	22415	5185	23	4659	1020	4446	1196
58	32439	33550	21997	4936	22	4413	918·3	4221	1181
57¾	31424	31932	21601	4718	21	4172	823·5	4001	1167
57½	30492	30463	21225	4525	20	3937	735·7	3785	1153
57¼	29633	29121	20865	4353	19	3708	654·4	3572	1141
57	28835	27887	20522	4199	18	3483	579·2	3364	1129
56	26123	23787	19276	3707	17	3263	509·8	3158	1117
55	23960	20638	18191	3348	16	3047	445·9	2956	1107
54	22168	18122	17228	3071	15	2835	387·1	2756	1096
53	20641	16058	16360	2850	14	2627	333·3	2559	1087
52	19316	14330	15570	2667	13	2423	284·2	2365	1078
51	18147	12860	14845	2511	12	2222	239·7	2173	1069
50	17103	11593	14174	2381	11	2024	199·4	1983	1061
49	16162	10491	13550	2266	10	1829	163·2	1796	1054
48	15306	9523	12966	2165	9	1636	131·0	1610	1046
47	14522	8667	12419	2075	8	1447	102·6	1426	1040
46	13799	7905	11903	1995	7	1259	77·9	1243	1033
45	13130	7224	11415	1923	6	1074	56·8	1062	1027
44	12506	6611	10953	1858	5	891	39·2	883	1022
43	11924	6058	10513	1798	4	709	24·9	704	1017
42	11377	5557	10094	1743	3	530	13·9	527	1012
41	10862	5101	9694	1693	2	352	6·2	351	1008
40	10375	4685	9310	1647	+1	175	1·5	175	1004
					0	0	0	0	1000
39	9914	4305	8943	1604	−1	174	1·5	174	997
38	9476	3957	8590	1564	2	347	6·0	348	994
37	9059	3637	8249	1527	3	519	13·5	521	991
36	8661	3342	7922	1493	4	690	24·0	694	989
35	8281	3071	7605	1461	5	860	37·4	867	987
34	7916	2820	7299	1431	6	1029	53·7	1040	985
33	7566	2588	7002	1402	7	1199	73·0	1213	984
32	7229	2374	6715	1376	8	1367	95·2	1386	983
31	6905	2175	6436	1351	9	1536	120·4	1560	982

IX. (*continued*).

$\lambda = 0·20$					$\lambda = 0·20$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
10°	1704	148·5	1733	981	46°	8567	4149	9404	1184
11	1872	179·6	1908	981	47	8814	4410	9706	1197
12	2040	213·8	2082	981	48	9067	4686	10017	1211
13	2208	251·1	2258	982	49	9326	4979	10337	1225
14	2376	291·5	2434	982	50	9591	5289	10669	1240
15	2544	335·1	2611	983	51	9863	5619	11011	1256
16	2713	382·0	2789	985	52	10142	5970	11366	1273
17	2883	432·2	2969	986	53	10429	6344	11733	1290
18	3053	485·8	3149	988	54	10723	6741	12114	1307
19	3224	543·0	3331	990	55	11026	7166	12510	1326
20	3395	603·8	3515	993	56	11337	7619	12921	1345
21	3568	668·3	3700	996	57	11657	8103	13350	1365
22	3741	736·7	3887	999	58	11988	8621	13797	1386
23	3916	809·0	4076	1002	59	12328	9177	14263	1408
24	4092	885·6	4267	1006	60	12679	9774	14751	1430
25	4269	966·4	4461	1010	61	13042	10415	15263	1453
26	4448	1052	4656	1015	62	13417	11105	15799	1477
27	4629	1142	4855	1019	63	13804	11849	16362	1502
28	4811	1237	5056	1024	64	14205	12653	16954	1528
29	4995	1337	5260	1030	65	14619	13523	17579	1555
30	5181	1442	5467	1036	66	15049	14465	18240	1582
31	5370	1553	5677	1042	67	15494	15489	18939	1611
32	5560	1670	5891	1048	68	15955	16602	19680	1640
33	5753	1793	6109	1055	69	16433	17817	20469	1670
34	5949	1922	6330	1062	70	16929	19144	21309	1701
35	6147	2059	6556	1070	71	17443	20597	22207	1733
36	6349	2202	6786	1078	72	17977	22194	23169	1765
37	6553	2353	7021	1087	73	18531	23952	24204	1798
38	6761	2513	7261	1096	74	19106	25894	25319	1832
39	6972	2681	7507	1105	75	19703	28046	26527	1866
40	7187	2858	7758	1115	76	20321	30439	27840	1900
41	7406	3045	8015	1125	77	20963	33111	29274	1934
42	7629	3242	8278	1136	78	21627	36109	30848	1967
43	7856	3450	8548	1147	79	22314	39490	32586	2001
44	8088	3671	8826	1159	80	23024	43326	34520	2034
45	8324	3903	9111	1171					

IX. (*continued*).

$\lambda = 0{\cdot}22$

ϕ	(x)	(y)	(t)	(v)
58°	41310	46280	23968	7654
57¾	39006	42610	23372	6910
57½	37096	39596	22833	6344
57¼	35465	37049	22338	5895
57	34044	34850	21879	5528
56¾	32786	32921	21451	5220
56½	31657	31208	21047	4956
56¼	30635	29671	20666	4728
56	29701	28280	20304	4528
55¾	28842	27012	19959	4349
55½	28047	25850	19629	4190
55¼	27308	24778	19313	4046
55	26617	23787	19009	3915
54	24235	20446	17899	3491
53	22304	17833	16923	3174
52	20684	15721	16050	2926
51	19292	13971	15258	2726
50	18076	12495	14534	2558
49	16997	11231	13866	2417
48	16030	10137	13245	2295
47	15154	9181	12667	2188
46	14354	8338	12124	2094
45	13620	7591	11613	2010
44	12941	6923	11131	1935
43	12311	6325	10673	1867
42	11722	5786	10239	1806
41	11171	5298	9825	1749
40	10653	4855	9429	1698

$\lambda = 0{\cdot}24$

ϕ	(x)	(y)	(t)	(v)
56½°	40352	43045	22908	7735
56¼	38012	39526	22331	6944
56	36090	36663	21812	6351
55¾	34461	34258	21337	5885
55½	33048	32193	20897	5507
55¼	31801	30387	20486	5192
55°	30686	28787	20101	4923
54¾	29679	27355	19736	4691
54½	28760	26061	19390	4489
54¼	27917	24884	19061	4309
54	27137	23806	18746	4148
53¾	26412	22813	18445	4004
53½	25736	21895	18155	3872
53¼	25102	21042	17876	3753
53	24506	20246	17607	3643
52	22423	17530	16617	3280
51	20705	15369	15738	3003
50	19247	13600	14945	2783
49	17984	12120	14222	2602
48	16871	10861	13556	2451
47	15879	9778	12940	2321
46	14984	8835	12366	2209
45	14171	8007	11829	2110
44	13426	7274	11323	2023
43	12739	6623	10846	1945
42	12102	6039	10394	1875
41	11510	5515	9964	1812
40	10955	5041	9555	1754

$\lambda = 0{\cdot}25$

ϕ	(x)	(y)	(t)	(v)
—	......	......	......	......
40°	6952	2733	7627	1079
41	7157	2908	7876	1088
42	7365	3092	8130	1097
43	7577	3286	8391	1106
44	7792	3491	8658	1117
45	8012	3707	8933	1127
46	8236	3935	9215	1138
47	8465	4176	9505	1150
48	8698	4430	9804	1162
49	8936	4700	10112	1174
50	9179	4985	10429	1188
51	9428	5287	10757	1201

IX. (*continued*).

$\lambda = 0{\cdot}25$

ϕ	(x)	(y)	(t)	(v)
52°	9683	5607	11095	1215
53	9944	5947	11446	1230
54	10211	6308	11809	1245
55	10485	6693	12186	1261
56	10767	7102	12577	1278
57	11055	7538	12984	1295
58	11352	8004	13407	1312
59	11657	8501	13849	1331
60	11970	9034	14310	1350
61	12293	9604	14792	1370
62	12625	10216	15296	1390
63	12967	10874	15826	1411
64	13320	11581	16382	1433
65	13684	12344	16967	1455
66	14059	13168	17585	1478
67	14447	14059	18237	1501
68	14846	15024	18927	1526
69	15259	16073	19660	1551
70	15686	17214	20439	1576
71	16126	18459	21270	1602
72	16582	19820	22159	1628
73	17052	21312	23112	1655
74	17538	22953	24137	1682
75	18039	24763	25245	1709
76	18557	26766	26446	1736
77	19091	28993	27755	1763
78	19642	31480	29189	1790
79	20210	34272	30769	1816
80	20794	37426	32522	1842

$\lambda = 0{\cdot}26$

ϕ	(x)	(y)	(t)	(v)
55°	38874	39352	21813	7608
54¾	36612	36137	21268	6825
54½	34756	33522	20776	6241
54¼	33183	31326	20326	5783
54	31819	29439	19910	5410
53¾	30615	27791	19522	5100
53½°	29540	26330	19156	4836
53¼	28567	25022	18811	4609
53	27681	23841	18483	4409
52¾	26867	22765	18171	4233
52½	26115	21780	17873	4075
52¼	25415	20873	17586	3933
52	24762	20033	17312	3805
51¾	24150	19253	17047	3687
51½	23575	18526	16792	3580
51¼	23031	17846	16545	3480
51	22517	17208	16306	3388
50	20698	14999	15421	3080
49	19173	13213	14626	2839
48	17864	11733	13905	2644
47	16719	10483	13244	2482
46	15703	9412	12632	2345
45	14792	8484	12063	2227
44	13966	7673	11531	2125
43	13212	6957	11031	2034
42	12519	6322	10559	1953
41	11878	5754	10112	1881
40	11282	5245	9688	1816

$\lambda = 0{\cdot}28$

ϕ	(x)	(y)	$(t$	(v)
53½°	36958	35386	20700	7288
53¼	34872	32580	20194	6570
53	33147	30279	19737	6026
52¾	31677	28336	19318	5597
52½	30397	26660	18928	5246
52¼	29264	25190	18564	4952
52	28248	23885	18221	4701
51¾	27329	22713	17897	4484
51½	26489	21652	17589	4294
51¼	25716	20685	17294	4125
51	25001	19798	17013	3974
50¾	24336	18980	16743	3838

IX. (*continued*).

$\lambda = 0{\cdot}28$

ϕ	(x)	(y)	(t)	(v)
50½°	23714	18222	16483	3714
50¼	23130	17518	16233	3601
50	22581	16860	15992	3497
49	20659	14608	15100	3154
48	19069	12810	14305	2891
47	17716	11333	13586	2682
46	16542	10095	12928	2510
45	15506	9040	12322	2366
44	14580	8129	11758	2243
43	13744	7336	11232	2136
42	12983	6638	10737	2042
41	12284	6021	10271	1960
40	11640	5470	9830	1885

$\lambda = 0{\cdot}30$

ϕ	(x)	(y)	(t)	(v)
52°	34743	31376	19582	6836
51¾	32892	29018	19122	6213
51½	31340	27057	18702	5732
51¼	30003	25384	18316	5347
51	28831	23930	17955	5028
50¾	27787	22647	17617	4759
50½	26847	21501	17298	4528
50¼	25993	20469	16995	4327
50	25210	19532	16707	4149
49¾	24487	18675	16431	3993
49½	23817	17886	16167	3850
49¼	23192	17158	15914	3721
49	22607	16482	15670	3605
48	20582	14191	14773	3224
47	18930	12386	13978	2940
46	17537	10918	13262	2716
45	16337	9696	12609	2535
44	15283	8660	12008	2384
43	14345	7770	11450	2255
42	13501	6996	10929	2144
41	12735	6318	10441	2048
40	12034	5719	9981	1962

$\lambda = 0{\cdot}30$

ϕ	(x)	(y)	(t)	(v)
39°	11388	5187	9546	1886
38	10789	4710	9133	1818
37	10232	4283	8740	1757
36	9711	3897	8365	1701
35	9221	3547	8005	1650
34	8760	3231	7661	1603
33	8324	2942	7330	1560
32	7910	2678	7012	1520
31	7516	2437	6704	1483
30	7141	2216	6407	1449
29	6783	2013	6120	1417
28	6440	1827	5842	1387
27	6111	1656	5571	1359
26	5795	1498	5309	1333
25	5490	1352	5053	1309
24	5196	1219	4805	1286
23	4912	1095	4562	1265
22	4638	981·3	4325	1244
21	4371	876·4	4093	1225
20	4113	779·9	3866	1207
19	3862	691·0	3644	1190
18	3618	609·4	3427	1174
17	3381	534·5	3213	1159
16	3149	465·9	3003	1145
15	2923	403·2	2797	1131
14	2702	346·0	2595	1119
13	2486	294·2	2395	1107
12	2275	247·3	2198	1095
11	2068	205·1	2004	1084
10	1864	167·4	1813	1074
9	1665	134·0	1623	1065
8	1469	94·7	1436	1055
7	1276	79·3	1251	1047
6	1086	57·7	1068	1039
5	899	39·7	887	1031
4	714	25·2	707	1024
3	533	14·0	528	1017
2	353	6·2	351	1011
+1	176	1·5	175	1006
0	0	0	0	1000

IX. (*continued*).

$\lambda = 0{\cdot}30$				
ϕ	(x)	(y)	(t)	(v)
−1°	174	1·5	174	995
2	346	6·0	347	990
3	516	13·5	520	986
4	685	23·8	692	982
5	853	37·0	864	978
6	1019	53·0	1035	975
7	1185	71·9	1206	972
8	1349	93·5	1377	970
9	1513	118·0	1548	967
10	1676	145·3	1719	965
11	1839	175·4	1890	964
12	2000	208·3	2061	962
13	2162	244·1	2233	961
14	2323	282·8	2406	961
15	2484	324·4	2579	960
16	2645	369·0	2753	960
17	2805	416·7	2928	960
18	2966	467·4	3103	961
19	3127	521·3	3280	961
20	3289	578·5	3458	962
21	3451	639·0	3638	963
22	3613	702·9	3819	965
23	3776	770·4	4001	967
24	3940	841·5	4186	969
25	4104	916·4	4372	972
26	4269	995·2	4560	974
27	4435	1078	4750	977
28	4603	1165	4943	981
29	4771	1257	5138	984
30	4941	1353	5336	988
31	5112	1454	5537	993
32	5285	1560	5740	997
33	5459	1671	5947	1002
34	5636	1787	6158	1007
35	5814	1910	6371	1013
36	5994	2038	6589	1019
37	6176	2173	6811	1025
38	6361	2315	7037	1032
39	6548	2464	7268	1039

$\lambda = 0{\cdot}30$				
ϕ	(x)	(y)	(t)	(v)
40°	6737	2620	7504	1046
41	6930	2784	7745	1054
42	7125	2957	7991	1062
43	7323	3139	8244	1070
44	7525	3330	8502	1079
45	7730	3531	8768	1088
46	7938	3744	9040	1098
47	8151	3967	9319	1108
48	8367	4203	9607	1119
49	8588	4453	9903	1129
50	8813	4716	10208	1141
51	9042	4995	10523	1153
52	9276	5289	10848	1165
53	9516	5601	11184	1178
54	9761	5932	11531	1191
55	10011	6284	11892	1205
56	10268	6657	12265	1219
57	10530	7054	12653	1234
58	10800	7477	13057	1250
59	11076	7927	13477	1265
60	11359	8408	13915	1282
61	11649	8921	14372	1299
62	11948	9471	14850	1316
63	12254	10060	15351	1334
64	12569	10692	15877	1353
65	12893	11372	16429	1372
66	13227	12103	17011	1392
67	13569	12892	17625	1412
68	13923	13744	18274	1432
69	14286	14667	18961	1453
70	14660	15668	19691	1475
71	15045	16756	20468	1497
72	15442	17942	21297	1519
73	15850	19238	22185	1541
74	16271	20658	23139	1563
75	16704	22220	24168	1586
76	17149	23943	25282	1609
77	17607	25852	26494	1631
78	18078	27976	27819	1653
79	18561	30354	29277	1675
80	19057	33032	30893	1696

IX. (*continued*).

$\lambda = 0{\cdot}32$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
50½°	32378	27524	18478	6317
50¼	30781	25595	18064	5800
50	29418	23963	17683	5391
49¾	28229	22552	17330	5055
49½	27176	21314	16999	4775
49¼	26232	20213	16688	4535
49	25376	19224	16392	4327
48¾	24594	18328	16111	4145
48½	23873	17510	15843	3983
48¼	23206	16760	15586	3838
48	22586	16067	15340	3708
47¾	22005	15425	15103	3589
47½	21460	14828	14874	3481
47¼	20947	14270	14653	3381
47	20461	13747	14439	3289
46	18752	11944	13646	2983
45	17324	10491	12933	2745
44	16101	9289	12286	2554
43	15033	8275	11691	2397
42	14087	7407	11139	2264
41	13238	6656	10625	2150
40	12469	5999	10144	2050
39	11766	5420	9690	1963
38	11120	4906	9261	1886
37	10523	4447	8854	1816
36	9967	4036	8466	1754
35	9448	3665	8096	1697
34	8961	3330	7743	1645
33	8502	3027	7403	1598
32	8068	2750	7077	1555
31	7657	2499	6763	1514
30	7267	2269	6460	1477

$\lambda = 0{\cdot}34$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
49¼°	31586	25808	17806	6321
49	29992	23965	17404	5789
48¾	28636	22412	17034	5370
48½	27459	21075	16691	5030
48¼	26418	19904	16370	4745
48	25486	18864	16068	4503
47¾	24642	17931	15782	4294
47½	23872	17087	15510	4111
47¼	23164	16318	15251	3948
47	22509	15612	15002	3803
46¾	21900	14962	14764	3673
46½	21330	14359	14534	3554
46¼	20796	13798	14313	3446
46	20293	13275	14099	3347
45	18533	11482	13308	3019
44	17076	10050	12601	2768
43	15836	8873	11960	2569
42	14758	7884	11372	2406
41	13806	7042	10828	2268
40	12954	6315	10321	2151
39	12185	5680	9846	2050
38	11484	5122	9399	1961
37	10840	4628	8976	1882
36	10244	4187	8575	1812
35	9692	3793	8194	1749
34	9175	3438	7829	1691
33	8692	3118	7481	1639
32	8236	2827	7147	1592
31	7806	2564	6825	1548
30	7399	2324	6516	1508

$\lambda = 0{\cdot}35$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
–	......	......	......	......
40°	6539	2516	7389	1016
41	6720	2671	7623	1023
42	6904	2834	7862	1030
43	7091	3005	8107	1037
44	7280	3184	8357	1045
45	7472	3373	8614	1053

IX. (*continued*).

$\lambda = 0.35$

ϕ	(x)	(y)	(t)	(v)
46°	7667	3572	8877	1062
47	7865	3781	9148	1070
48	8067	4001	9425	1080
49	8272	4233	9711	1089
50	8481	4478	10005	1099
51	8694	4736	10308	1110
52	8911	5009	10621	1121
53	9133	5297	10944	1132
54	9359	5603	11278	1144
55	9589	5926	11623	1156
56	9825	6269	11981	1168
57	10066	6633	12353	1181
58	10312	7020	12739	1195
59	10564	7432	13140	1209
60	10822	7870	13559	1223
61	11087	8337	13995	1238
62	11358	8836	14451	1253
63	11635	9369	14927	1269
64	11920	9940	15427	1285
65	12212	10553	15951	1302
66	12512	11211	16503	1319
67	12819	11918	17084	1336
68	13135	12681	17698	1354
69	13459	13505	18347	1372
70	13793	14396	19036	1391
71	14135	15363	19768	1410
72	14486	16414	20549	1429
73	14847	17559	21384	1448
74	15218	18811	22280	1467
75	15599	20185	23245	1486
76	15989	21696	24289	1506
77	16390	23366	25422	1525
78	16801	25221	26660	1544
79	17222	27291	28020	1562
80	17653	29618	29525	1580

$\lambda = 0.36$

ϕ	(x)	(y)	(t)	(v)
48°	30527	23909	17111	6217
47¾	28984	22203	16724	5695
47½	27672	20764	16369	5285
47¼	26532	19525	16040	4950
47	25523	18439	15731	4671
46¾	24620	17475	15441	4433
46½	23803	16609	15166	4228
46¼	23056	15826	14905	4048
46	22370	15112	14655	3888
45¾	21735	14457	14416	3746
45½	21144	13853	14186	3617
45¼	20591	13293	13965	3501
45	20073	12773	13752	3394
44	18271	11001	12966	3047
43	16792	9597	12266	2784
42	15541	8449	11632	2578
41	14457	7490	11051	2409
40	13504	6676	10515	2269
39	12653	5974	10015	2149
38	11885	5363	9548	2046
37	11187	4827	9108	1956
36	10547	4353	8692	1876
35	9956	3931	8297	1805
34	9407	3554	7922	1742
33	8895	3215	7563	1684
32	8416	2910	7220	1632
31	7965	2634	6891	1584
30	7539	2383	6575	1540

$\lambda = 0.38$

ϕ	(x)	(y)	(t)	(v)
47°	30981	23758	16798	6660
46¾	29236	21894	16395	6016
46½	27787	20360	16029	5527
46¼	26549	19060	15692	5139
46	25468	17937	15379	4821
45¾	24510	16949	15085	4555

IX. (*continued*).

$\lambda = 0{\cdot}38$

ϕ	(x)	(y)	(t)	(v)
45½°	23651	16070	14808	4328
45¼	22871	15280	14546	4131
45	22157	14563	14296	3958
44¾	21501	13909	14057	3804
44½	20892	13309	13828	3667
44¼	20325	12754	13608	3543
44	19795	12240	13396	3430
43	17963	10501	12617	3065
42	16471	9132	11925	2793
41	15214	8020	11300	2580
40	14130	7094	10728	2408
39	13179	6309	10200	2265
38	12332	5635	9708	2144
37	11569	5049	9248	2039
36	10876	4536	8816	1948
35	10241	4083	8407	1868
34	9655	3681	8019	1797
33	9112	3321	7650	1732
32	8606	2998	7297	1675
31	8132	2708	6960	1622
30	7686	2445	6636	1574

$\lambda = 0{\cdot}40$

ϕ	(x)	(y)	(t)	(v)
46°	31301	23464	16461	7091
45¾	29352	21454	16042	6312
45½	27773	19840	15667	5741
45¼	26446	18496	15325	5300
45	25304	17348	15008	4945
44¾	24300	16349	14713	4653
44½	23406	15466	14436	4406
44¼	22600	14678	14173	4194
44	21867	13966	13924	4009
43¾	21194	13320	13686	3846
43½	20573	12728	13459	3701
43¼	19997	12183	13241	3570
43	19459	11679	13031	3453

$\lambda = 0{\cdot}40$

ϕ	(x)	(y)	(t)	(v)
42¾°	18955	11211	12829	3345
42½	18481	10775	12633	3247
42¼	18034	10367	12444	3157
42	17611	9984	12261	3074
41	16114	8659	11578	2794
40	14859	7586	10963	2577
39	13780	6696	10401	2402
38	12834	5944	9882	2257
37	11994	5299	9399	2134
36	11238	4740	8947	2029
35	10552	4250	8522	1938
34	9924	3819	8120	1857
33	9346	3435	7739	1785
32	8810	3094	7377	1721
31	8310	2787	7030	1664
30	7842	2512	6699	1611
29	7403	2263	6380	1564
28	6988	2038	6074	1520
27	6596	1834	5779	1480
26	6223	1648	5494	1443
25	5869	1479	5219	1408
24	5530	1324	4952	1377
23	5207	1184	4693	1347
22	4897	1055	4441	1319
21	4599	937·8	4196	1294
20	4312	830·6	3957	1270
19	4036	732·8	3724	1247
18	3769	643·5	3496	1226
17	3511	562·1	3274	1206
16	3261	488·0	3056	1188
15	3019	420·8	2842	1170
14	2783	359·9	2633	1153
13	2554	304·9	2427	1138
12	2331	255·5	2225	1123
11	2114	211·2	2026	1109
10	1901	171·9	1831	1096
9	1694	137·2	1638	1084
8	1491	106·9	1447	1072
7	1293	80·7	1260	1061

IX. (*continued*).

$\lambda = 0{\cdot}40$					$\lambda = 0{\cdot}40$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
6°	1098	58·5	1074	1051	34°	5362	1672	6002	960
5	907	40·2	891	1041	35	5524	1783	6206	964
4	720	25·4	709	1033	36	5687	1899	6413	968
3	536	14·1	530	1023	37	5851	2021	6623	973
2	354	6·2	352	1015	38	6017	2148	6838	978
1	176	1·5	175	1007	39	6185	2282	7057	983
0	0	0	0	1000					
1	173	1·5	174	993	40	6355	2422	7280	989
2	344	6·0	347	987	41	6526	2568	7508	995
3	513	13·4	519	981	42	6700	2722	7740	1001
4	681	23·6	690	975	43	6876	2883	7978	1007
5	846	36·6	861	970	44	7054	3052	8221	1014
6	1009	52·3	1030	966	45	7235	3230	8470	1021
7	1171	70·8	1200	961	46	7418	3416	8725	1029
8	1332	91·9	1368	958	47	7604	3613	8987	1036
9	1491	115·7	1537	954	48	7793	3819	9256	1045
10	1649	142·2	1705	950	49	7985	4036	9532	1053
11	1806	171·3	1874	947	50	8180	4264	9816	1062
12	1963	203·1	2042	945	51	8378	4505	10109	1071
13	2118	237·5	2211	942	52	8581	4759	10411	1081
14	2273	274·6	2380	940	53	8786	5028	10722	1091
15	2427	314·5	2549	938	54	8996	5311	11044	1101
16	2580	357·0	2719	937	55	9210	5611	11376	1112
17	2733	402·4	2890	936	56	9428	5928	11721	1123
18	2886	450·5	3061	935	57	9650	6264	12078	1135
19	3038	501·5	3233	935	58	9877	6621	12448	1147
20	3191	555·5	3406	934	59	10109	7000	12834	1159
21	3343	612·5	3580	934	60	10347	7402	13235	1172
22	3495	672·5	3755	935	61	10589	7831	13652	1185
23	3648	735·7	3932	935	62	10837	8287	14088	1199
24	3800	802·1	4110	936	63	11091	8775	14544	1213
25	3954	871·9	4289	937	64	11350	9296	15021	1227
26	4107	945·1	4471	939	65	11616	9853	15522	1242
27	4261	1022	4654	940	66	11888	10451	16047	1256
28	4416	1102	4839	942	67	12167	11092	16601	1272
29	4571	1187	5027	945	68	12453	11783	17185	1288
30	4728	1275	5216	947	69	12746	12527	17802	1304
31	4885	1368	5409	950	70	13046	13330	18456	1320
32	5043	1464	5603	953	71	13354	14200	19150	1336
33	5202	1566	5801	957	72	13670	15143	19890	1353

IX. (*continued*).

$\lambda = 0{\cdot}40$

ϕ	(x)	(y)	(t)	(v)
73°	13993	16169	20681	1372
74	14325	17289	21528	1387
75	14665	18514	22439	1403
76	15012	19861	23424	1420
77	15369	21345	24493	1437
78	15733	22991	25659	1453
79	16106	24824	26939	1469
80	16487	26881	28355	1485

$\lambda = 0{\cdot}42$

ϕ	(x)	(y)	(t)	(v)
44½°	27597	19185	15282	5908
44¼	26202	17820	14937	5419
44	25012	16666	14620	5034
43¾	23977	15670	14325	4719
43½	23059	14796	14048	4456
43¼	22237	14019	13788	4232
43	21492	13320	13541	4037
42¾	20811	12688	13305	3867
42½	20184	12111	13081	3716
42¼	19603	11581	12865	3581
42	19062	11092	12658	3460
41	17212	9454	11900	3071
40	15721	8179	11229	2786
39	14474	7151	10625	2566
38	13405	6300	10073	2390
37	12469	5582	9563	2244
36	11639	4967	9090	2121
35	10893	4435	8646	2016
34	10217	3970	8229	1924
33	9598	3560	7835	1844
32	9028	3197	7461	1772
31	8499	2873	7105	1708
30	8007	2583	6765	1651

$\lambda = 0{\cdot}44$

ϕ	(x)	(y)	(t)	(v)
43½°	27235	18385	14871	6008
43¼	25799	17027	14526	5485
43	24585	15890	14211	5077
42¾	23534	14914	13919	4747
42½	22608	14062	13646	4474
42¼	21780	13307	13389	4241
42	21033	12631	13145	4041
41¾	20351	12020	12913	3867
41½	19725	11463	12692	3712
41¼	19146	10953	12481	3575
41	18608	10483	12277	3451
40¾	18105	10048	12081	3339
40½	17633	9644	11892	3237
40¼	17190	9267	11710	3143
40	16771	8913	11533	3057
39	15295	7696	10875	2770
38	14064	6716	10283	2549
37	13009	5906	9742	2372
36	12088	5224	9243	2227
35	11270	4641	8779	2104
34	10536	4137	8345	1999
33	9871	3696	7937	1908
32	9263	3308	7550	1828
31	8702	2965	7183	1757
30	8183	2659	6834	1693

$\lambda = 0{\cdot}45$

ϕ	(x)	(y)	(t)	(v)
–	......	......	.....	......
40°	6184	2335	7177	963
41	6347	2474	7399	968
42	6511	2620	7625	974
43	6678	2772	7856	980
44	6846	2932	8093	986
45	7017	3100	8335	992

IX. (*continued*).

$\lambda = 0{\cdot}45$

ϕ	(x)	(y)	(t)	(v)
46°	7190	3276	8582	998
47	7365	3460	8837	1005
48	7543	3654	9097	1013
49	7723	3858	9365	1020
50	7906	4072	9640	1028
51	8092	4298	9924	1037
52	8281	4536	10215	1045
53	8473	4786	10516	1054
54	8669	5051	10827	1063
55	8868	5330	11148	1073
56	9071	5625	11480	1083
57	9278	5937	11825	1093
58	9489	6268	12182	1104
59	9703	6619	12552	1115
60	9923	6991	12938	1127
61	10147	7387	13339	1138
62	10375	7808	13758	1150
63	10609	8257	14195	1163
64	10847	8735	14653	1176
65	11091	9247	15132	1189
66	11341	9795	15635	1202
67	11596	10382	16165	1216
68	11857	11012	16723	1230
69	12124	11690	17312	1244
70	12397	12422	17936	1259
71	12677	13212	18598	1273
72	12963	14068	19302	1288
73	13256	14997	20055	1303
74	13556	16010	20860	1318
75	13863	17116	21726	1333
76	14176	18329	22661	1348
77	14497	19666	23675	1363
78	14825	21144	24781	1377
79	15159	22790	25993	1391
80	15500	24633	27334	1405

$\lambda = 0{\cdot}46$

ϕ	(x)	(y)	(t)	(v)
42½°	26673	17443	14432	6027
42¼	25232	16127	14093	5488
42	24019	15031	13783	5070
41¾	22973	14092	13496	4734
41½	22053	13275	13228	4456
41¼	21232	12552	12976	4222
41	20492	11906	12737	4019
40¾	19818	11323	12510	3844
40½	19200	10792	12294	3688
40¼	18629	10306	12087	3550
40	18098	9859	11888	3426
39¾	17603	9445	11696	3314
39½	17139	9061	11511	3211
39¼	16702	8703	11333	3118
39	16290	8367	11160	3032
38	14839	7213	10517	2745
37	13630	6284	9938	2526
36	12595	5518	9409	2350
35	11691	4873	8922	2205
34	10890	4322	8468	2083
33	10170	3846	8043	1979
32	9518	3430	7643	1889
31	8921	3064	7264	1810
30	8372	2741	6905	1739

$\lambda = 0{\cdot}48$

ϕ	(x)	(y)	(t)	(v)
41½°	25913	16376	13970	5959
41¼	24504	15135	13639	5425
41	23319	14100	13337	5011
40¾	22296	13216	13058	4679
40½	21398	12445	12797	4403
40¼	20597	11763	12552	4171

IX. (*continued*).

$\lambda = 0{\cdot}48$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
40°	19874	11154	12320	3972
39¾	19216	10605	12099	3798
39½	18613	10105	11888	3644
39¼	18055	9647	11686	3508
39	17537	9226	11493	3385
38¾	17053	8836	11306	3274
38½	16600	8474	11126	3173
38¼	16174	8136	10952	3081
38	15771	7820	10784	2996
37	14355	6733	10157	2713
36	13174	5859	9592	2496
35	12163	5137	9077	2322
34	11280	4530	8600	2180
33	10497	4012	8157	2060
32	9794	3563	7742	1957
31	9156	3173	7350	1868
30	8573	2829	6980	1790

$\lambda = 0{\cdot}5$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
41°	28738	18464	14241	7506
40¾	26617	16628	13839	6499
40½	24972	15217	13486	5810
40¼	23630	14076	13169	5301
40	22497	13120	12878	4904
39¾	21517	12302	12609	4584
39½	20654	11587	12357	4319
39¼	19883	10954	12119	4094
39	19186	10387	11895	3900
38¾	18552	9876	11681	3731
38½	17969	9410	11477	3582
38¼	17430	8983	11281	3449
38	16929	8590	11093	3330
37¾	16461	8226	10912	3221
37½	16022	7888	10737	3123
37¼	15609	7572	10568	3033
37	15219	7277	10405	2949

$\lambda = 0{\cdot}5$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
36¾°	14849	6999	10246	2873
36½	14498	6738	10092	2801
36¼	14163	6492	9942	2735
36	13844	6259	9796	2673
35	12698	5441	9246	2460
34	11715	4765	8744	2290
33	10856	4196	8280	2150
32	10093	3710	7847	2033
31	9408	3290	7442	1932
30	8787	2924	7059	1844
29	8218	2602	6697	1767
28	7694	2318	6353	1699
27	7208	2065	6025	1638
26	6756	1839	5711	1584
25	6332	1636	5410	1534
24	5933	1455	5120	1489
23	5557	1291	4840	1448
22	5200	1144	4570	1410
21	4862	1010	4309	1375
20	4540	889·8	4056	1343
19	4232	780·9	3810	1313
18	3938	682·3	3571	1285
17	3656	593·3	3338	1259
16	3384	512·8	3111	1235
15	3123	440·3	2890	1213
14	2870	375·1	2673	1192
13	2627	316·6	2461	1172
12	2391	264·3	2253	1153
11	2162	217·8	2049	1136
10	1940	176·6	1849	1120
9	1725	140·5	1652	1104
8	1515	109·1	1459	1090
7	1310	82·2	1268	1076
6	1111	59·5	1080	1063
5	916	40·7	895	1051
4	725	25·7	712	1040
3	538	14·2	531	1029
2	356	6·2	352	1019
1	176	1·5	175	1009
0	0	0	0	1000

IX. (*continued*).

λ = 0·5					λ = 0·5				
φ	(x)	(y)	(t)	(v)	φ	(x)	(y)	(t)	(v)
1°	173	1·5	174	992	40°	6024	2254	7079	940
2	343	6·0	346	984	41	6179	2386	7295	944
3	511	13·3	517	976	42	6335	2525	7516	949
4	676	23·4	688	969	43	6493	2669	7741	954
5	839	36·2	857	963	44	6653	2821	7971	959
6	1000	51·6	1025	956	45	6814	2980	8207	965
7	1158	69·7	1192	951	46	6978	3146	8448	971
8	1315	90·4	1359	945	47	7143	3321	8695	977
9	1470	113·6	1526	940	48	7311	3504	8948	984
10	1624	139·3	1692	936	49	7481	3696	9208	990
11	1776	167·5	1857	932	50	7653	3898	9475	998
12	1927	198·2	2023	928	51	7828	4110	9750	1005
13	2077	231·3	2189	924	52	8006	4333	10033	1013
14	2225	267·0	2354	921	53	8186	4569	10324	1021
15	2373	305·2	2520	918	54	8370	4816	10625	1029
16	2520	345·9	2686	916	55	8556	5078	10936	1038
17	2666	389·2	2853	913	56	8746	5354	11257	1047
18	2811	435·0	3020	912	57	8939	5645	11589	1056
19	2956	483·4	3187	910	58	9135	5954	11934	1066
20	3100	534·5	3356	909	59	9335	6280	12292	1076
21	3244	588·3	3525	907	60	9539	6627	12663	1086
22	3388	644·9	3695	907	61	9747	6994	13050	1097
23	3531	704·3	3866	906	62	9959	7385	13453	1108
24	3674	766·6	4039	906	63	10176	7800	13874	1119
25	3818	831·9	4213	906	64	10396	8243	14314	1131
26	3961	900·3	4388	907	65	10622	8716	14775	1142
27	4104	971·8	4565	907	66	10852	9221	15258	1155
28	4248	1047	4743	908	67	11087	9762	15767	1167
29	4392	1125	4924	909	68	11327	10342	16302	1179
30	4537	1207	5106	911	69	11573	10965	16867	1192
31	4682	1292	5291	912	70	11824	11636	17464	1205
32	4827	1381	5478	914	71	12080	12361	18098	1218
33	4974	1474	5668	917	72	12342	13144	18772	1232
34	5121	1572	5860	919	73	12610	13994	19491	1245
35	5268	1673	6055	922	74	12883	14918	20261	1259
36	5417	1779	6253	925	75	13163	15926	21088	1272
37	5567	1890	6454	928	76	13448	17030	21980	1286
38	5718	2006	6658	932	77	13740	18245	22946	1299
39	5870	2127	6867	936	78	14037	19588	23999	1312
					79	14340	21080	25154	1325
					80	14650	22750	26430	1337

IX. (*continued*).

$\lambda = 0.55$					$\lambda = 0.6$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
38½°	24976	14445	12857	6390	36¾°	26084	14566	12462	7665
38¼	23391	13190	12522	5698	36½	23919	12956	12080	6500
38	22103	12178	12220	5189	36¼	22295	11760	11749	5740
37¾	21018	11335	11945	4795	36	20996	10812	11455	5196
37½	20082	10613	11690	4478	35¾	19914	10029	11187	4780
37¼	19258	9984	11451	4216	35½	18986	9364	10939	4450
37	18524	9428	11227	3995	35¼	18175	8788	10709	4179
36¾	17861	8931	11014	3804	35	17455	8281	10492	3952
36½	17257	8482	10812	3638	34¾	16807	7830	10287	3758
36¼	16703	8074	10619	3492	34½	16219	7424	10092	3589
36	16191	7700	10434	3361	34¼	15680	7055	9907	3441
35¾	15715	7356	10256	3244	34	15183	6718	9729	3310
35½	15271	7037	10085	3138	33¾	14723	6409	9558	3192
35¼	14854	6742	9919	3042	33½	14293	6123	9394	3085
35	14462	6466	9759	2954	33¼	13891	5858	9235	2989
34	13091	5523	9166	2663	33	13512	5611	9082	2901
33	11957	4772	8632	2443	32	12193	4770	8512	2612
32	10991	4156	8145	2268	31	11103	4102	8001	2393
31	10149	3640	7696	2126	30	10176	3556	7534	2220
30	9405	3202	7278	2006	29	9371	3100	7104	2080
29	8739	2824	6886	1905	28	8659	2713	6703	1963
28	8135	2496	6517	1817	27	8021	2381	6326	1863
27	7583	2209	6167	1740	26	7444	2093	5972	1776
26	7076	1956	5834	1672	25	6917	1841	5636	1701
25	6606	1732	5517	1611	24	6431	1620	5316	1634
24	6168	1532	5213	1557	23	5982	1425	5011	1575
23	5759	1354	4922	1507	22	5564	1252	4718	1522
22	5374	1195	4641	1463	21	5173	1097	4437	1474
21	5011	1052	4371	1422	20	4805	959·9	4167	1430
20	4668	923·3	4109	1384	19	4458	837·0	3906	1390
19	4342	807·8	3856	1350	18	4130	727·1	3653	1354
18	4031	703·9	3611	1320	17	3818	628·8	3409	1320
17	3735	610·4	3372	1289	16	3521	540·8	3171	1289
16	3451	526·4	3140	1261	15	3238	462·1	2940	1260
15	3179	450·9	2914	1236	14	2966	391·9	2716	1234
					13	2706	329·4	2496	1209

IX. (*continued*).

$\lambda = 0{\cdot}6$					$\lambda = 0{\cdot}6$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
12°	2456	273·9	2282	1186	28°	4096	996·7	4654	877
11	2215	224·8	2073	1164	29	4230	1070	4829	877
10	1982	181·7	1868	1144	30	4365	1146	5005	878
9	1757	144·1	1667	1126	31	4499	1225	5183	879
8	1540	111·5	1470	1108	32	4634	1308	5363	880
7	1329	83·7	1277	1091	33	4769	1394	5545	881
6	1124	60·4	1086	1076	34	4905	1484	5729	883
5	924	41·2	899	1061	35	5041	1578	5916	885
4	730	25·9	714	1047	36	5178	1675	6106	887
3	541	14·3	532	1034	37	5316	1777	6299	889
2	357	6·3	353	1022	38	5454	1883	6494	892
1	176	1·5	175	1011	39	5593	1994	6694	894
0	0	0	0	1000					
1	173	1·5	174	990	40	5734	2109	6897	898
2	342	5·9	346	980	41	5875	2230	7103	901
3	508	13·2	516	971	42	6017	2356	7314	905
4	672	23·2	685	963	43	6160	2487	7528	909
5	832	35·8	853	955	44	6305	2625	7747	913
6	990	51·0	1020	947	45	6451	2768	7971	917
7	1146	68·7	1186	940	46	6599	2918	8200	922
8	1299	88·9	1351	934	47	6748	3076	8435	927
9	1450	111·5	1515	928	48	6899	3240	8675	932
10	1599	136·5	1679	922	49	7051	3413	8921	938
11	1747	163·8	1842	917	50	7206	3593	9174	944
12	1893	193·5	2005	912	51	7362	3783	9434	950
13	2037	225·5	2167	907	52	7521	3982	9701	956
14	2180	259·8	2330	903	53	7681	4192	9976	963
15	2322	296·5	2493	899	54	7844	4412	10259	970
16	2462	335·5	2655	896	55	8009	4643	10552	977
17	2602	376·8	2818	893	56	8177	4888	10854	984
18	2741	420·5	2981	890	57	8347	5145	11166	992
19	2878	466·6	3144	887	58	8520	5417	11490	1000
20	3015	515·1	3309	885	59	8696	5704	11825	1008
21	3152	566·1	3473	883	60	8875	6008	12174	1016
22	3288	619·6	3639	881	61	9057	6330	12536	1026
23	3423	675·7	3805	880	62	9242	6671	12912	1035
24	3558	734·3	3972	879	63	9431	7033	13305	1044
25	3693	795·7	4141	878	64	9623	7418	13715	1054
26	3827	859·9	4311	878	65	9819	7829	14145	1064
27	3962	926·8	4482	877	66	10018	8266	14595	1074

IX. (*continued*).

$\lambda = 0{\cdot}6$

ϕ	(x)	(y)	(t)	(v)
67°	10221	8734	15067	1084
68	10428	9234	15564	1095
69	10640	9770	16088	1105
70	10855	10346	16642	1116
71	11075	10967	17228	1127
72	11298	11636	17852	1138
73	11527	12361	18516	1150
74	11760	13147	19226	1161
75	11997	14004	19988	1172
76	12239	14940	20809	1183
77	12486	15968	21698	1194
78	12737	17102	22666	1205
79	12993	18360	23726	1216
80	13253	19765	24897	1226

$\lambda = 0{\cdot}65$

ϕ	(x)	(y)	(t)	(v)
27°	8546	2590	6508	2016
26	7877	2256	6126	1904
25	7276	1970	5768	1808
24	6732	1722	5429	1725
23	6235	1505	5108	1653
22	5776	1315	4802	1589
21	5352	1148	4509	1532
20	4956	1000	4228	1481
19	4585	868·8	3959	1434
18	4237	752·1	3699	1392
17	3908	648·4	3447	1354
16	3596	556·0	3204	1319
15	3300	473·9	2968	1287

$\lambda = 0{\cdot}65$

ϕ	(x)	(y)	(t)	(v)
$34\frac{1}{2}$°	21805	10898	11170	6030
$34\frac{1}{4}$	20392	9932	10869	5379
34	19244	9153	10599	4901
$33\frac{3}{4}$	18276	8504	10352	4530
$33\frac{1}{2}$	17441	7948	10122	4231
$33\frac{1}{4}$	16705	7463	9908	3985
33	16049	7035	9706	3776
$32\frac{3}{4}$	15457	6652	9514	3597
$32\frac{1}{2}$	14917	6307	9332	3440
$32\frac{1}{4}$	14421	5992	9158	3302
32	13963	5705	8991	3180
$31\frac{3}{4}$	13538	5440	8831	3069
$31\frac{1}{2}$	13140	5195	8676	2969
$31\frac{1}{4}$	12767	4968	8527	2879
31	12416	4756	8382	2796
30	11187	4031	7845	2522
29	10170	3455	7361	2315
28	9302	2984	6918	2150

$\lambda = 0{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
$33\frac{1}{4}$°	24731	12342	11197	8443
33	22230	10709	10803	6832
$32\frac{3}{4}$	20481	9579	10475	5889
$32\frac{1}{2}$	19135	8717	10187	5250
$32\frac{1}{4}$	18041	8024	9928	4782
32	17120	7445	9692	4420
$31\frac{3}{4}$	16324	6951	9472	4128
$31\frac{1}{2}$	15625	6520	9267	3887
$31\frac{1}{4}$	15000	6139	9074	3683
31	14437	5799	8891	3508
$30\frac{3}{4}$	13924	5492	8716	3355
$30\frac{1}{2}$	13452	5213	8550	3221
$30\frac{1}{4}$	13017	4957	8390	3101
30	12612	4722	8236	2993
$29\frac{3}{4}$	12234	4505	8088	2896
$29\frac{1}{2}$	11879	4303	7945	2807
$29\frac{1}{4}$	11545	4115	7807	2726
29	11230	3940	7672	2652
28	10118	3336	7171	2404

IX. (*continued*).

$\lambda = 0\cdot7$					$\lambda = 0\cdot7$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
27°	9190	2852	6718	2214	13°	1999	220·0	2147	891
26	8393	2455	6301	2063	14	2137	253·1	2306	886
25	7696	2122	5915	1938	15	2274	288·3	2466	881
24	7077	1840	5553	1833	16	2409	325·7	2625	877
23	6519	1597	5213	1743	17	2542	365·3	2784	873
22	6013	1388	4891	1666	18	2675	407·1	2943	869
21	5548	1205	4585	1597	19	2806	451·0	3103	866
20	5120	1044	4293	1537	20	2937	497·2	3263	863
19	4722	903·6	4014	1483	21	3066	545·7	3424	860
18	4351	779·4	3745	1435	22	3195	596·4	3585	858
17	4003	669·6	3487	1391	23	3323	649·4	3747	856
16	3675	572·4	3237	1351	24	3451	704·9	3909	854
15	3365	486·5	2996	1314	25	3578	762·8	4073	852
14	3071	410·5	2762	1281	26	3704	823·2	4238	851
13	2792	343·4	2535	1250	27	3831	886·1	4403	850
12	2525	284·2	2314	1222	28	3957	951·7	4571	849
11	2270	232·4	2099	1196	29	4082	1020	4739	849
10	2026	187·1	1889	1171	30	4208	1091	4909	849
9	1791	147·8	1683	1148	31	4334	1165	5081	849
8	1565	114·0	1483	1127	32	4460	1242	5255	849
7	1347	85·3	1286	1107	33	4585	1323	5431	850
6	1137	61·3	1093	1089	34	4712	1406	5609	851
5	933	41·7	904	1072	35	4838	1493	5789	852
4	736	26·2	717	1055	36	4965	1583	5972	853
3	544	14·4	534	1040	37	5092	1677	6157	854
2	358	6·3	354	1026	38	5219	1775	6345	856
1	177	1·5	176	1013	39	5348	1877	6536	858
0	0	0	0	1000					
1	172	1·5	173	988	40	5477	1984	6731	861
2	341	5·9	345	977	41	5606	2094	6928	863
3	506	13·1	515	967	42	5737	2210	7130	866
4	667	23·0	683	957	43	5868	2330	7335	869
5	825	35·4	850	947	44	6001	2456	7545	872
6	980	50·3	1015	939	45	6134	2587	7759	876
7	1133	67·7	1179	931	46	6268	2724	7977	880
8	1283	87·4	1342	923	47	6404	2867	8201	884
9	1430	109·5	1504	916	48	6541	3016	8430	888
10	1575	133·8	1666	909	49	6679	3173	8664	893
11	1719	160·3	1827	903	50	6819	3336	8905	897
12	1860	189·1	1987	897	51	6961	3508	9152	902

IX. (*continued*).

$\lambda = 0{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
52°	7104	3688	9405	908
53	7248	3876	9666	913
54	7395	4074	9935	919
55	7543	4282	10212	925
56	7693	4501	10498	932
57	7846	4732	10794	938
58	8000	4974	11100	945
59	8157	5231	11417	952
60	8317	5501	11745	959
61	8479	5787	12087	967
62	8643	6090	12442	975
63	8810	6412	12812	983
64	8980	6752	13198	991
65	9153	7115	13601	999
66	9329	7501	14024	1008
67	9508	7912	14467	1017
68	9690	8352	14933	1026
69	9875	8822	15424	1035
70	10064	9327	15942	1044
71	10256	9870	16491	1054
72	10451	10454	17073	1063
73	10651	11086	17693	1073
74	10853	11771	18356	1083
75	11060	12516	19066	1092
76	11270	13328	19831	1102
77	11483	14219	20659	1111
78	11701	15200	21560	1121
79	11922	16288	22546	1130
80	12146	17501	23633	1139

$\lambda = 0{\cdot}75$

ϕ	(x)	(y)	(t)	(v)
31°	18513	8007	9693	5376
30¾	17376	7327	9433	4855
30½	16433	6768	9197	4460
30¼	15626	6296	8980	4147
30	14922	5887	8777	3892
29¾°	14298	5528	8587	3678
29½	13737	5209	8407	3496
29¼	13228	4923	8236	3338
29	12762	4663	8073	3199
28¾	12333	4426	7917	3076
28½	11935	4209	7766	2966
28¼	11564	4009	7622	2867
28	11217	3823	7482	2777
27	10014	3196	6966	2486
26	9030	2706	6503	2269
25	8199	2309	6081	2100
24	7480	1981	5692	1964
23	6846	1705	5329	1850
22	6280	1470	4989	1755
21	5768	1269	4667	1672
20	5301	1094	4363	1600
19	4872	942·0	4072	1537
18	4474	809·1	3795	1481
17	4105	692·5	3528	1430
16	3759	590·0	3272	1385
15	3434	499·9	3025	1344

$\lambda = 0{\cdot}8$

ϕ	(x)	(y)	(t)	(v)
30°	20497	8850	9720	6999
29¾	18699	7817	9398	5914
29½	17357	7054	9119	5214
29¼	16286	6451	8871	4714
29	15395	5955	8645	4335
28¾	14633	5534	8437	4033
28½	13967	5171	8243	3787
28¼	13376	4851	8060	3580
28	12845	4567	7887	3404
27¾	12362	4312	7723	3251
27½	11920	4081	7566	3116
27¼	11513	3870	7416	2997

IX. (*continued*).

$\lambda = 0{\cdot}8$

ϕ	(x)	(y)	(t)	(v)
27°	11135	3676	7272	2891
26¾	10783	3498	7133	2795
26½	10452	3332	6999	2707
26¼	10142	3178	6869	2628
26	9849	3035	6743	2554
25¾	9572	2900	6621	2487
25½	9309	2774	6502	2425
25¼	9059	2655	6386	2367
25	8820	2543	6274	2312
24	7962	2152	5849	2127
23	7228	1832	5458	1980
22	6585	1566	5096	1860
21	6015	1341	4757	1759
20	5502	1150	4437	1672
19	5036	984·5	4135	1597
18	4609	841·6	3847	1532
17	4215	717·3	3572	1474
16	3849	608·9	3309	1422
15	3507	514·2	3055	1376
14	3187	431·3	2811	1334
13	2886	358·9	2575	1296
12	2601	295·6	2347	1261
11	2330	240·6	2125	1229
10	2073	192·9	1909	1200
9	1827	151·8	1700	1173
8	1592	116·7	1495	1148
7	1367	87·0	1295	1124
6	1151	62·3	1099	1103
5	943	42·3	908	1083
4	742	26·4	720	1064
3	547	14·6	535	1046
2	359	6·3	354	1030
1	177	1·6	176	1015
0	0	0	0	1000

$\lambda = 0{\cdot}85$

ϕ	(x)	(y)	(t)	(v)
28¼°	16942	6586	8740	5392
28	15809	5981	8488	4823
27¾	14885	5491	8260	4402
27½	14103	5082	8052	4075
27¼	13426	4732	7859	3810
27	12830	4426	7677	3591
26¾	12296	4156	7506	3406
26½	11814	3914	7344	3246
26¼	11374	3696	7189	3106
26	10970	3497	7042	2984
25¾	10596	3316	6900	2874
25½	10248	3149	6763	2775
25¼	9923	2995	6631	2686
25	9617	2852	6504	2605
24	8555	2367	6031	2340
23	7682	1987	5605	2142
22	6940	1679	5216	1986
21	6296	1426	4855	1860
20	5726	1213	4519	1755
19	5217	1032	4202	1665
18	4755	877·5	3903	1589
17	4333	744·4	3619	1522
16	3945	629·3	3347	1463
15	3585	529·5	3087	1410

$\lambda = 0{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
27½°	19528	7703	8909	7561
27¼	17512	6658	8575	6150
27	16090	5930	8296	5315
26¾	14992	5373	8050	4747
26½	14096	4924	7829	4328
26¼	13341	4550	7627	4003
26	12688	4229	7439	3742
25¾	12113	3950	7262	3525

IX. (*continued*).

$\lambda = 0{\cdot}9$					$\lambda = 0{\cdot}9$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
25½°	11599	3704	7097	3342	7°	1109	65·8	1167	912
25¼	11135	3484	6939	3184	8	1253	84·7	1326	902
25	10712	3285	6789	3047	9	1393	105·7	1485	893
24¾	10323	3105	6645	2926	10	1531	128·8	1642	884
24½	9963	2940	6508	2818	11	1666	153·8	1798	876
24¼	9629	2789	6375	2721	12	1799	180·8	1953	869
24	9316	2649	6247	2633	13	1930	209·8	2108	861
23¾	9023	2519	6123	2553	14	2058	240·6	2262	855
23½	8747	2398	6004	2480	15	2185	273·4	2416	849
23¼	8486	2285	5887	2413	16	2310	308·0	2569	843
23	8238	2179	5774	2351	17	2433	344·5	2722	838
22	7361	1816	5351	2142	18	2555	382·9	2875	833
21	6621	1524	4965	1981	19	2675	423·1	3027	828
20	5981	1285	4608	1851	20	2794	465·3	3180	824
19	5418	1085	4276	1743	21	2912	509·3	3333	820
18	4916	917·1	3963	1652	22	3028	555·3	3487	816
17	4462	774·0	3668	1574	23	3144	603·3	3641	813
16	4049	651·4	3388	1506	24	3259	653·2	3795	810
15	3668	545·8	3121	1447	25	3373	705·2	3950	807
14	3316	454·8	2865	1394	26	3487	759·3	4106	805
13	2989	376·1	2619	1347	27	3599	815·5	4263	803
12	2682	308·1	2382	1304	28	3711	873·9	4420	801
11	2394	249·5	2153	1266	29	3823	934·5	4579	799
10	2123	199·1	1932	1230	30	3934	997·5	4739	798
9	1865	156·0	1717	1198	31	4045	1063	4901	797
8	1621	119·4	1508	1169	32	4156	1131	5064	796
7	1388	88·8	1305	1142	33	4267	1201	5228	796
6	1165	63·4	1106	1117	34	4377	1274	5395	795
5	952	42·8	912	1094	35	4488	1350	5563	795
4	747	26·7	723	1072	36	4598	1429	5734	795
3	550	14·7	537	1052	37	4708	1511	5907	796
2	361	6·4	355	1034	38	4819	1595	6082	796
1	177	1·6	176	1016	39	4930	1684	6259	797
0	0	0	0	1000					
1	172	1·5	173	985	40	5041	1775	6440	799
2	339	5·9	344	971	41	5153	1870	6623	800
3	501	12·9	512	957	42	5264	1969	6810	801
4	659	22·6	678	945	43	5377	2072	7000	803
5	813	34·7	843	933	44	5490	2180	7193	805
6	963	49·1	1006	922	45	5603	2291	7391	808

IX. (*continued*).

$\lambda = 0{\cdot}9$					$\lambda = 0{\cdot}95$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
46°	5717	2407	7592	810	26°	16125	5758	8057	5724
47	5832	2528	7798	813	25¾	14878	5153	7798	5007
48	5948	2655	8008	816	25½	13895	4682	7569	4506
49	6065	2787	8223	819	25¼	13084	4297	7361	4129
50	6182	2924	8444	823	25	12395	3974	7169	3832
51	6301	3068	8670	826	24¾	11794	3696	6991	3592
52	6421	3219	8902	830	24½	11263	3452	6823	3391
53	6541	3376	9141	834	24¼	10787	3236	6665	3220
54	6664	3541	9386	838	24	10355	3043	6514	3073
55	6787	3714	9639	843	23¾	9961	2868	6371	2944
56	6912	3895	9899	847	23½	9597	2709	6234	2830
57	7038	4086	10168	852	23¼	9261	2564	6102	2727
58	7165	4286	10446	857	23	8947	2430	5974	2636
59	7294	4497	10733	863	22	7872	1984	5506	2343
60	7425	4719	11031	869	21	7002	1641	5087	2129
61	7558	4953	11340	874	20	6273	1368	4706	1964
62	7692	5200	11661	880	19	5645	1146	4355	1833
63	7828	5462	11995	886	18	5094	961·5	4028	1724
64	7966	5739	12343	893	17	4603	806·5	3721	1633
65	8107	6033	12706	899	16	4160	675·3	3431	1555
66	8249	6345	13086	906	15	3757	563·4	3156	1487
67	8393	6677	13484	913					
68	8540	7031	13902	920					
69	8689	7409	14342	927					
70	8840	7814	14806	934					
71	8993	8247	15296	942					
72	9149	8714	15817	949					
73	9308	9217	16370	958					
74	9469	9761	16960	964					
75	9633	10351	17593	972					

IX. (*continued*).

$\gamma = 1 \cdot 0$

ϕ	(x)	(y)	(t)	(v)
25¼°	17685	6312	8079	7314
25	15804	5430	7763	5931
24¾	14484	4818	7499	5118
24½	13467	4351	7267	4567
24¼	12638	3976	7059	4162
24	11940	3664	6868	3848
23¾	11337	3397	6690	3595
23½	10806	3164	6524	3386
23¼	10332	2959	6368	3210
23	9904	2777	6219	3058
22¾	9514	2612	6077	2926
22½	9156	2462	5942	2809
22¼	8824	2326	5812	2705
22	8516	2201	5687	2612
21¾	8228	2085	5566	2528
21½	7957	1978	5449	2451
21¼	7703	1878	5336	2381
21	7462	1785	5226	2317
20	6613	1468	4815	2102
19	5903	1216	4442	1938
18	5293	1012	4098	1806
17	4758	842·8	3777	1698
16	4281	701·6	3477	1608
15	3852	582·5	3193	1530
14	3461	481·5	2923	1463
13	3103	395·4	2666	1404
12	2772	321·9	2419	1352
11	2464	259·2	2183	1306
10	2176	205·8	1955	1264
9	1905	160·5	1735	1226
8	1650	122·4	1521	1192
7	1409	90·6	1314	1160
6	1180	64·5	1113	1132
5	962	43·4	917	1105
4	753	27·0	726	1081
3	554	14·8	539	1058
2	362	6·4	356	1038
1	178	1·6	176	1018
0	0	0	0	1000

$\lambda = 1 \cdot 1$

ϕ	(x)	(y)	(t)	(v)
23¼°	15625	5037	7305	6688
23	14026	4353	7018	5513
22¾	12875	3868	6775	4797
22½	11976	3493	6561	4302
22¼	11239	3189	6367	3934
22	10614	2935	6189	3646
21¾	10071	2717	6023	3413
21½	9592	2527	5867	3219
21¼	9163	2359	5720	3055
21	8775	2209	5581	2913
20¾	8421	2074	5448	2790
20½	8094	1951	5320	2680
20¼	7792	1839	5198	2583
20	7511	1736	5080	2496
19¾	7248	1641	4966	2416
19½	7002	1553	4856	2343
19¼	6769	1471	4749	2277
19	6549	1395	4645	2216
18	5771	1135	4257	2013
17	5119	928·8	3903	1857
16	4558	762·5	3577	1732
15	4066	625·8	3273	1630
14	3627	512·3	2987	1544
13	3231	417·2	2717	1470
12	2870	337·2	2460	1406
11	2539	269·8	2215	1350
10	2233	213·0	1979	1300
9	1948	165·3	1753	1256
8	1682	125·5	1535	1216
7	1432	92·5	1325	1180
6	1195	65·6	1120	1147
5	972	44·0	922	1117
4	759	27·3	729	1090
3	557	14·9	540	1065
2	363	6·4	356	1041
1	178	1·6	176	1020
0	0	0	0	1000
1	171	1·5	173	981
2	336	5·8	343	964
3	496	12·8	510	948

IX. (*continued*).

$\lambda = 1{\cdot}1$					$\lambda = 1{\cdot}1$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
4°	650	22·2	674	933	43°	4977	1869	6714	751
5	800	34·0	836	919	44	5075	1962	6895	752
6	946	48·0	996	906	45	5174	2059	7079	753
7	1087	64·1	1155	894	46	5273	2160	7267	755
8	1224	82·2	1311	882	47	5373	2265	7458	757
9	1358	102·2	1465	871	48	5473	2375	7654	759
10	1489	124·1	1619	861	49	5574	2489	7854	761
11	1617	147·9	1771	852	50	5676	2608	8059	764
12	1743	173·3	1922	843	51	5778	2731	8269	766
13	1865	200·5	2071	834	52	5881	2861	8484	769
14	1986	229·4	2221	827	53	5984	2996	8705	772
15	2104	260·0	2369	819	54	6089	3137	8932	776
16	2220	292·2	2517	812	55	6194	3285	9166	779
17	2335	326·1	2664	806	56	6301	3440	9406	783
18	2447	361·6	2811	800	57	6408	3602	9654	787
19	2558	398·7	2958	794	58	6517	3773	9911	791
20	2667	437·4	3104	789	59	6626	3952	10175	795
21	2775	477·8	3251	784	60	6737	4140	10449	799
22	2882	519·9	3397	780	61	6849	4338	10734	804
23	2988	563·6	3544	776	62	6963	4547	11029	809
24	3092	609·1	3692	772	63	7078	4768	11335	814
25	3196	656·2	3840	768	64	7194	5002	11655	819
26	3299	705·2	3988	765	65	7312	5249	11988	824
27	3400	755·9	4137	762	66	7431	5511	12336	830
28	3501	808·5	4286	760	67	7552	5789	12701	836
29	3602	863·0	4437	757	68	7675	6086	13083	841
30	3702	919·5	4589	755	69	7799	6401	13485	847
					70	7926	6739	13909	853
31	3801	978·0	4742	753					
32	3900	1039	4896	752					
33	3998	1101	5051	751	$\lambda = 1{\cdot}2$				
34	4097	1166	5208	750					
35	4195	1234	5367	749					
36	4293	1303	5527	748	ϕ	(x)	(y)	(t)	(v)
37	4390	1376	5690	748					
38	4488	1451	5854	748	$21\frac{1}{2}$°	13864	4059	6640	6133
39	4585	1528	6021	748	$21\frac{1}{4}$	12496	3524	6378	5134
40	4683	1609	6190	748	21	11490	3135	6154	4503
41	4781	1692	6362	749	$20\frac{3}{4}$	10694	2831	5954	4059
42	4879	1779	6536	750	$20\frac{1}{2}$	10035	2583	5773	3724

IX. (*continued*).

$\lambda = 1 \cdot 2$

ϕ	(x)	(y)	(t)	(v)
20¼°	9473	2375	5606	3460
20	8984	2195	5450	3246
19¾	8550	2038	5304	3065
19½	8161	1899	5166	2912
19¼	7807	1775	5034	2780
19	7484	1663	4908	2664
18¾	7186	1561	4788	2562
18½	6910	1468	4672	2470
18¼	6653	1383	4561	2388
18	6412	1304	4453	2313
17	5578	1041	4053	2071
16	4895	838·2	3693	1891
15	4317	677·8	3363	1752
14	3817	548·2	3058	1639
13	3375	442·1	2773	1545
12	2980	354·4	2503	1466
11	2622	281·5	2248	1399
10	2295	220·9	2005	1340
9	1994	170·5	1773	1288
8	1715	128·8	1550	1241
7	1455	94·5	1335	1200
6	1211	66·7	1128	1163
5	982	44·7	927	1130
4	765	27·6	732	1099
3	560	15·0	542	1071
2	365	6·5	357	1046
1	178	1·6	176	1022
0	0	0	0	1000

$\lambda = 1 \cdot 3$

ϕ	(x)	(y)	(t)	(v)
20°	12597	3391	6108	5844
19¾	11351	2940	5860	4910
19½	10428	2611	5647	4316
19¼	9696	2354	5458	3896
19	9088	2143	5286	3578

$\lambda = 1 \cdot 3$

ϕ	(x)	(y)	(t)	(v)
18¾°	8569	1966	5127	3327
18½	8116	1813	4978	3122
18¼	7714	1679	4839	2951
18	7354	1561	4707	2804
17¾	7026	1456	4581	2678
17½	6726	1360	4461	2567
17¼	6450	1274	4346	2469
17	6193	1195	4235	2381
16¾	5954	1122	4129	2302
16½	5730	1055	4026	2230
16¼	5520	993·5	3926	2165
16	5321	936·0	3829	2104
15	4622	742·0	3466	1906
14	4039	591·1	3137	1754
13	3539	470·9	2833	1634
12	3101	373·8	2550	1536
11	2712	294·5	2284	1453
10	2361	229·5	2033	1383
9	2043	176·1	1793	1322
8	1750	132·3	1565	1269
7	1479	96·7	1346	1222
6	1228	68·0	1135	1180
5	993	45·3	931	1142
4	772	27·9	734	1108
3	563	15·1	543	1078
2	366	6·5	358	1049
1	179	1·6	177	1024
0	0	0	0	1000
1	171	1·5	173	978
2	334	5·8	342	958
3	491	12·6	507	939
4	642	21·8	670	922
5	788	33·3	830	906
6	929	46·9	988	891
7	1065	62·4	1143	877
8	1198	79·8	1296	864
9	1326	99·0	1447	852
10	1451	119·9	1597	840
11	1572	142·4	1745	829
12	1691	166·5	1892	819

IX. (*continued*).

$\lambda = 1 \cdot 3$

ϕ	(x)	(y)	(t)	(v)
13°	1807	192·2	2038	810
14	1920	219·4	2182	801
15	2031	248·1	2326	793
16	2140	278·2	2469	785
17	2246	309·8	2611	778
18	2351	342·8	2753	771
19	2454	377·2	2894	765
20	2555	413·1	3035	759
21	2655	450·4	3176	753
22	2753	489·1	3317	748
23	2850	529·3	3458	743
24	2946	571·0	3599	739
25	3041	614·2	3740	735
26	3135	658·9	3882	731
27	3228	705·1	4024	727
28	3320	753·0	4167	724
29	3411	802·5	4311	721
30	3502	853·7	4455	719
31	3591	906·7	4600	716
32	3681	961·4	4747	714
33	3770	1018	4895	713
34	3858	1076	5044	711
35	3946	1137	5194	710
36	4034	1200	5346	709
37	4121	1264	5500	708
38	4209	1331	5655	707
39	4296	1401	5813	706
40	4383	1472	5973	706
41	4470	1547	6135	706
42	4557	1624	6299	707
43	4644	1704	6467	707
44	4731	1787	6637	708
45	4819	1873	6810	709
46	4907	1962	6987	710
47	4995	2055	7167	711
48	5083	2151	7351	712
49	5172	2251	7538	714
50	5261	2356	7730	716
51	5351	2465	7927	718

$\lambda = 1 \cdot 3$

ϕ	(x)	(y)	(t)	(v)
52°	5441	2578	8129	720
53	5532	2696	8335	722
54	5623	2820	8548	725
55	5715	2949	8766	728
56	5808	3084	8991	731
57	5902	3226	9222	734
58	5996	3374	9461	737
59	6092	3530	9708	741
60	6188	3693	9964	745
61	6285	3865	10228	748
62	6383	4046	10503	752
63	6483	4237	10788	757
64	6583	4439	11085	761
65	6685	4652	11394	766

$\lambda = 1 \cdot 4$

ϕ	(x)	(y)	(t)	(v)
18¾°	11923	3004	5724	5942
18½	10655	2576	5476	4920
18¼	9736	2271	5265	4291
18	9016	2035	5079	3853
17¾	8424	1844	4910	3527
17½	7921	1685	4754	3271
17¼	7484	1548	4610	3064
17	7098	1429	4474	2891
16¾	6751	1324	4345	2745
16½	6438	1230	4223	2619
16¼	6151	1146	4107	2508
16	5888	1070	3995	2411
15¾	5643	1000	3888	2323
15½	5416	936·5	3784	2245
15¼	5203	877·9	3684	2174
15	5003	823·8	3587	2109
14	4305	643·2	3227	1898
13	3729	504·8	2901	1741

IX. (*continued*).

$\lambda = 1\cdot4$

ϕ	(x)	(y)	(t)	(v)
12°	3239	396·0	2601	1616
11	2812	309·1	2323	1515
10	2434	238·9	2062	1431
9	2095	182·1	1815	1359
8	1787	136·0	1581	1298
7	1505	98·9	1357	1245
6	1245	69·2	1143	1197
5	1004	46·0	936	1155
4	778	28·2	737	1118
3	567	15·2	545	1084
2	368	6·5	358	1053
1	179	1·6	177	1026
0	0	0	0	1000

$\lambda = 1\cdot5$

ϕ	(x)	(y)	(t)	(v)
17¾°	12110	2932	5513	6843
17½	10532	2431	5238	5333
17¼	9485	2103	5015	4518
17	8701	1861	4821	3989
16¾	8073	1671	4648	3611
16½	7550	1515	4491	3323
16¼	7102	1383	4345	3094
16	6710	1270	4209	2906
15¾	6362	1171	4081	2749
15½	6048	1083	3959	2615
15¼	5763	1004	3844	2499
15	5502	933·8	3733	2396
14	4632	708·6	3331	2085
13	3953	545·3	2977	1870
12	3396	421·7	2658	1710
11	2924	325·4	2365	1585
10	2513	249·3	2093	1484
9	2151	188·6	1838	1400
8	1826	140·0	1597	1329
7	1532	101·3	1368	1269

$\lambda = 1\cdot5$

ϕ	(x)	(y)	(t)	(v)
6°	1263	70·6	1150	1217
5	1015	46·6	941	1169
4	785	28·5	740	1128
3	570	15·4	546	1091
2	369	6·6	359	1058
1	179	1·6	177	1027
0	0	0	0	1000
1	170	1·5	172	975
2	332	5·7	341	952
3	487	12·4	505	931
4	635	21·5	666	911
5	777	32·7	824	893
6	914	45·8	979	877
7	1046	60·8	1132	861
8	1173	77·6	1282	847
9	1296	95·9	1430	833
10	1415	115·9	1577	820
11	1531	137·4	1721	809
12	1644	160·3	1864	798
13	1753	184·6	2006	787
14	1860	210·2	2146	778
15	1965	237·2	2286	769
16	2067	265·5	2424	760
17	2167	295·1	2562	752
18	2264	325·9	2699	745
19	2360	358·0	2835	738
20	2455	391·4	2972	732
21	2547	426·0	3107	726
22	2638	462·0	3243	720
23	2728	499·2	3378	715
24	2817	537·6	3514	710
25	2904	577·5	3650	705
26	2990	618·6	3785	701
27	3076	661·1	3922	697
28	3160	705·0	4059	693
29	3243	750·4	4196	690
30	3326	797·2	4334	687
31	3408	845·6	4473	684
32	3490	895·5	4613	682
33	3571	947·0	4754	680

IX. (*continued*).

$\lambda = 1{\cdot}5$

ϕ	(x)	(y)	(t)	(v)
34°	3651	1000	4896	678
35	3731	1055	5039	676
36	3811	1112	5184	675
37	3890	1171	5330	673
38	3969	1231	5478	672
39	4048	1294	5628	671
40	4126	1359	5780	671
41	4205	1426	5934	670
42	4283	1495	6090	670
43	4362	1567	6249	670
44	4440	1641	6410	670
45	4519	1718	6574	671
46	4597	1798	6741	672
47	4676	1882	6912	672
48	4755	1968	7085	673
49	4834	2057	7263	675
50	4914	2151	7444	676
51	4994	2248	7630	678
52	5074	2349	7820	679
53	5155	2454	8015	681
54	5236	2564	8215	683
55	5318	2678	8421	686
56	5400	2798	8633	688
57	5483	2923	8851	691
58	5567	3054	9076	694
59	5651	3192	9308	697
60	5736	3337	9548	700

$\lambda = 1{\cdot}6$

ϕ	(x)	(y)	(t)	(v)
16½°	9924	2153	4927	5320
16¼	8890	1849	4706	4472
16	8125	1628	4516	3932
15¾	7517	1455	4346	3550
15½	7013	1314	4192	3260
15¼	6582	1195	4050	3032

$\lambda = 1{\cdot}6$

ϕ	(x)	(y)	(t)	(v)
15°	6206	1094	3918	2845
14¾	5872	1005	3793	2689
14½	5572	926·8	3675	2556
14¼	5300	857·0	3562	2441
14	5051	794·3	3455	2340
13¾	4821	737·5	3351	2251
13½	4608	685·9	3252	2171
13¼	4409	638·6	3157	2100
13	4223	595·2	3064	2034
12	3578	451·8	2720	1822
11	3049	344·1	2410	1666
10	2600	260·9	2126	1543
9	2211	195·7	1862	1445
8	1868	144·3	1614	1363
7	1560	103·7	1381	1294
6	1282	71·9	1159	1235
5	1027	47·4	947	1183
4	792	28·8	744	1138
3	574	15·5	548	1098
2	370	6·6	360	1062
1	180	1·6	177	1029
0	0	0	0	1000

$\lambda = 1{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
15½°	8910	1789	4554	4884
15¼	8025	1545	4350	4173
15	7352	1363	4173	3702
14¾	6810	1219	4014	3362
14½	6356	1101	3868	3100
14¼	5965	1000	3734	2891
14	5622	914·0	3607	2720
13¾	5316	838·6	3489	2575
13½	5041	771·8	3376	2452
13¼	4790	712·2	3268	2344
13	4560	658·5	3165	2250

IX. (*continued*).

$\lambda = 1{\cdot}7$					$\lambda = 1{\cdot}7$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
12°	3793	488·1	2791	1961	25°	2781	545·1	3567	679
11	3191	365·6	2460	1761	26	2861	583·2	3697	674
10	2697	273·8	2162	1611	27	2939	622·6	3829	670
9	2277	203·5	1887	1494	28	3017	663·1	3960	666
8	1913	148·9	1632	1400	29	3094	705·0	4092	663
7	1590	106·4	1393	1321	30	3171	748·1	4225	659
6	1301	73·4	1167	1255	31	3246	792·6	4358	656
5	1039	48·1	952	1198	32	3321	838·5	4492	654
4	799	29·2	747	1148	33	3395	885·8	4627	651
3	577	15·6	550	1105	34	3469	934·5	4763	649
2	372	6·6	360	1066	35	3542	984·9	4900	647
1	180	1·6	177	1031	36	3615	1037	5039	645
0	0	0	0	1000					
1	170	1·5	172	972	37	3688	1090	5178	643
2	330	5·7	339	946	38	3760	1146	5320	642
3	482	12·3	503	923	39	3832	1203	5463	641
4	627	21·2	662	901	40	3903	1262	5608	640
5	766	32·0	818	881	41	3975	1323	5754	639
6	898	44·8	971	863	42	4046	1386	5903	639
7	1026	59·3	1121	846	43	4117	1451	6055	639
8	1148	75·5	1268	830	44	4188	1519	6208	639
9	1266	93·1	1414	816	45	4260	1589	6365	639
10	1381	112·2	1557	802	46	4331	1661	6524	639
11	1491	132·7	1698	790	47	4402	1736	6686	640
12	1598	154·5	1838	778	48	4474	1814	6851	640
13	1702	177·6	1976	767	49	4545	1895	7020	641
14	1804	201·9	2112	756	50	4617	1980	7192	642
15	1902	227·4	2248	747	51	4689	2067	7369	643
16	1998	254·0	2382	738	52	4762	2158	7549	645
17	2092	281·8	2516	729	53	4834	2253	7734	646
18	2184	310·8	2649	722	54	4908	2352	7924	648
19	2274	340·8	2781	714	55	4981	2455	8119	650
20	2362	372·1	2913	707	56	5055	2562	8320	652
21	2449	404·4	3044	701	57	5129	2675	8526	654
22	2534	437·9	3175	695	58	5204	2793	8739	657
23	2617	472·5	3305	689	59	5280	2916	8959	659
24	2700	508·2	3436	684	60	5356	3045	9186	662

IX. (*continued*).

$\lambda = 1\cdot8$

ϕ	(x)	(y)	(t)	(v)
14½°	7729	1417	4148	4263
14¼	7034	1239	3969	3743
14	6484	1101	3809	3376
13¾	6029	988·2	3664	3099
13½	5639	893·9	3530	2880
13¼	5300	813·2	3405	2702
13	4999	743·0	3287	2553
12¾	4729	681·2	3176	2427
12½	4484	626·3	3070	2317
12¼	4259	577·0	2968	2221
12	4052	532·6	2871	2136
11	3356	390·6	2516	1873
10	2805	288·4	2200	1688
9	2349	212·0	1915	1549
8	1961	153·9	1651	1439
7	1622	109·2	1406	1350
6	1321	74·9	1176	1276
5	1051	48·9	957	1213
4	806	29·5	750	1159
3	581	15·7	551	1112
2	373	6·7	361	1070
1	180	1·6	177	1033
0	0	0	0	1000

$\lambda = 1\cdot9$

ϕ	(x)	(y)	(t)	(v)
14°	8142	1475	4116	4980
13¾	7240	1253	3912	4170
13½	6576	1092	3737	3659
13¼	6051	966·5	3581	3298
13	5616	865·0	3440	3027
12¾	5244	780·2	3310	2813
12½	4921	707·7	3188	2638
12¼	4634	644·7	3073	2493
12	4376	589·4	2965	2369
11	3548	420·6	2577	2011
10	2926	305·1	2242	1777

$\lambda = 1\cdot9$

ϕ	(x)	(y)	(t)	(v)
9°	2428	221·5	1944	1610
8	2012	159·3	1671	1482
7	1655	112·2	1420	1381
6	1342	76·5	1185	1298
5	1064	49·7	963	1229
4	813	29·9	753	1171
3	585	15·9	553	1119
2	375	6·7	362	1075
1	181	1·6	178	1035
0	0	0	0	1000
1	169	1·5	172	969
2	328	5·6	338	940
3	478	12·1	500	915
4	620	20·8	658	891
5	755	31·5	812	870
6	884	43·9	963	850
7	1007	57·9	1111	832
8	1126	73·5	1255	815
9	1239	90·5	1398	799
10	1349	108·8	1538	785
11	1454	128·4	1676	772
12	1557	149·1	1812	759
13	1656	171·1	1947	747
14	1752	194·2	2080	737
15	1845	218·3	2212	727
16	1936	243·5	2343	717
17	2025	269·8	2473	708
18	2111	297·1	2602	700
19	2196	325·4	2730	692
20	2279	354·7	2857	685
21	2360	385·0	2984	678
22	2439	416·3	3111	672
23	2517	448·7	3237	666
24	2594	482·1	3363	661
25	2670	516·5	3490	655
26	2744	552·0	3616	651
27	2818	588·6	3742	646
28	2890	626·3	3869	642
29	2962	665·1	3996	638
30	3032	705·1	4124	635

IX. (*continued*).

$\lambda = 1\cdot9$

φ	(x)	(y)	(t)	(v)
31°	3102	746·3	4252	631
32	3171	788·7	4381	628
33	3240	832·4	4511	626
34	3308	877·5	4641	623
35	3376	923·9	4773	621
36	3443	971·7	4906	619
37	3509	1021	5040	617
38	3576	1072	5176	616
39	3642	1124	5313	614
40	3708	1179	5452	613
41	3773	1235	5592	612
42	3838	1293	5735	612
43	3904	1352	5880	611
44	3969	1414	6027	611
45	4034	1478	6176	611
46	4099	1544	6328	611
47	4164	1613	6483	611
48	4229	1684	6641	612
49	4295	1758	6802	612
50	4360	1835	6967	613
51	4426	1914	7135	614
52	4492	1997	7308	615
53	4558	2083	7484	616
54	4624	2173	7665	618
55	4691	2267	7851	619
56	4758	2365	8042	621
57	4826	2467	8239	623

$\lambda = 2\cdot0$

φ	(x)	(y)	(t)	(v)
13°	6608	1068	3650	3924
12¾	6015	932·7	3485	3471
12½	5540	826·1	3338	3146
12¼	5142	738·9	3203	2897
12	4801	665·6	3078	2700
11¾	4503	602·8	2962	2537
11½	4237	548·1	2852	2401

$\lambda = 2\cdot0$

φ	(x)	(y)	(t)	(v)
11¼°	3998	500·0	2747	2285
11	3780	457·2	2648	2184
10	3065	324·4	2289	1882
9	2515	232·1	1975	1679
8	2068	165·1	1693	1529
7	1691	115·4	1434	1414
6	1365	78·2	1194	1322
5	1077	50·5	969	1245
4	821	30·2	757	1181
3	588	16·0	555	1126
2	376	6·7	362	1079
1	181	1·6	178	1037
0	0	0	0	1000

$\lambda = 2\cdot1$

φ	(x)	(y)	(t)	(v)
12½°	6556	1027	3544	4137
12¼	5909	885·1	3372	3596
12	5404	776·7	3221	3223
11¾	4990	689·6	3083	2947
11½	4639	617·4	2957	2731
11¼	4335	556·2	2840	2556
11	4066	503·3	2729	2411
10¾	3826	457·1	2625	2288
10½	3608	416·2	2526	2183
10¼	3409	379·7	2431	2090
10	3226	347·0	2340	2008
9	2611	244·0	2009	1757
8	2127	171·5	1715	1581
7	1728	118·8	1449	1450
6	1387	80·0	1203	1346
5	1091	51·3	975	1263
4	828	30·6	760	1193
3	592	16·2	557	1134
2	378	6·8	363	1083
1	181	1·6	178	1039
0	0	0	0	1000

IX. (*continued*).

$\lambda = 2\cdot 1$

ϕ	(x)	(y)	(t)	(v)
1°	169	1·5	171	965
2	326	5·6	337	934
3	474	12·0	498	906
4	613	20·5	654	881
5	745	30·9	807	858
6	871	43·0	955	837
7	990	56·6	1101	818
8	1104	71·6	1243	800
9	1214	88·0	1383	784
10	1319	105·6	1520	769
11	1420	124·3	1655	755
12	1518	144·2	1789	742
13	1612	165·1	1920	730
14	1704	187·1	2050	718
15	1793	210·0	2179	708
16	1879	234·0	2306	698
17	1963	258·8	2432	689
18	2045	284·6	2558	680
19	2125	311·3	2682	672
20	2203	338·9	2806	665
21	2279	367·5	2929	658
22	2354	396·9	3052	651
23	2427	427·3	3174	645
24	2499	458·6	3297	639
25	2570	490·9	3419	634
26	2640	524·1	3541	629
27	2708	558·3	3663	625
28	2776	593·5	3786	620
29	2842	629·7	3908	616
30	2908	667·0	4031	613
31	2973	705·3	4155	609
32	3038	744·8	4279	606
33	3102	785·4	4405	603
34	3165	827·3	4530	600
35	3227	870·4	4657	598
36	3290	914·7	4785	596
37	3351	960·5	4915	594
38	3413	1008	5045	592
39	3474	1056	5177	591

$\lambda = 2\cdot 1$

ϕ	(x)	(y)	(t)	(v)
40°	3535	1106	5310	590
41	3595	1158	5446	589
42	3656	1211	5583	588
43	3716	1267	5722	587
44	3776	1324	5863	587
45	3836	1383	6006	586
46	3896	1444	6152	586
47	3956	1507	6301	586
48	4015	1572	6452	586
49	4076	1640	6607	587
50	4136	1710	6765	587
51	4196	1784	6926	588
52	4257	1860	7091	589
53	4317	1939	7260	590
54	4378	2021	7433	591
55	4439	2107	7611	593

$\lambda = 2\cdot 2$

ϕ	(x)	(y)	(t)	(v)
12°	6398	965·9	3419	4254
11¾	5723	823·9	3243	3652
11½	5207	717·6	3090	3249
11¼	4788	633·4	2952	2955
11	4437	564·3	2826	2729
10¾	4134	506·0	2709	2548
10½	3867	456·0	2600	2398
10¼	3630	412·5	2496	2272
10	3415	374·2	2398	2164
9	2720	257·6	2045	1848
8	2193	178·5	1739	1639
7	1768	122·5	1464	1488
6	1411	81·8	1213	1373
5	1105	52·2	981	1280
4	836	31·0	763	1205
3	596	16·3	558	1142
2	379	6·8	364	1088
1	182	1·6	178	1041
0	0	0	0	1000

IX. (*continued*).

$\lambda = 2\cdot3$					$\lambda = 2\cdot3$				
ϕ	(x)	(y)	(t)	(v)	ϕ	(x)	(y)	(t)	(v)
$11\frac{1}{2}°$	6129	885·7	3273	4248	16°	1826	225·2	2271	681
$11\frac{1}{4}$	5459	750·9	3099	3628	17	1905	248·8	2394	671
11	4951	650·9	2947	3217	18	1983	273·2	2516	662
$10\frac{3}{4}$	4541	572·2	2811	2921	19	2059	298·5	2637	654
$10\frac{1}{2}$	4198	507·9	2687	2693	20	2132	324·6	2758	646
$10\frac{1}{4}$	3903	453·9	2572	2512	21	2204	351·6	2877	639
10	3645	407·7	2464	2363	22	2275	379·4	2997	632
$9\frac{3}{4}$	3414	367·5	2362	2237	23	2344	408·0	3116	626
$9\frac{1}{2}$	3206	332·3	2265	2130	24	2412	437·5	3234	620
$9\frac{1}{4}$	3017	301·0	2173	2036	25	2479	467·8	3352	615
9	2843	273·1	2085	1954	26	2544	499·0	3471	610
8	2264	186·3	1764	1704	27	2608	531·1	3589	605
7	1810	126·4	1480	1530	28	2672	564·1	3708	600
6	1437	83·8	1223	1400	29	2734	598·1	3827	596
5	1120	53·2	987	1299	30	2796	633·0	3946	593
4	844	31·4	767	1217	31	2857	668·9	4066	589
3	600	16·4	560	1150	32	2917	705·8	4186	586
2	381	6·8	364	1092	33	2977	743·7	4307	583
1	182	1·6	178	1043	34	3036	782·8	4429	580
0	0	0	0	1000	35	3094	823·0	4551	578
1	168	1·4	171	962	36	3152	864·3	4675	575
2	324	5·5	336	929	37	3210	906·9	4799	573
3	470	11·9	496	899	38	3267	950·8	4925	571
4	606	20·2	651	872	39	3324	996·0	5053	570
5	735	30·4	801	848	40	3380	1043	5181	568
6	857	42·1	948	825	41	3437	1091	5312	567
7	973	55·3	1091	805	42	3493	1140	5444	566
8	1084	69·8	1231	786	43	3549	1191	5578	565
9	1190	85·6	1368	769	44	3604	1244	5714	565
10	1291	102·5	1503	754	45	3660	1299	5852	564
11	1388	120·6	1635	739	46	3716	1356	5992	564
12	1482	139·6	1766	726	47	3771	1414	6135	564
13	1572	159·6	1894	713	48	3827	1475	6281	564
14	1659	180·6	2021	701	49	3882	1537	6430	564
15	1744	202·4	2147	691	50	3938	1603	6581	565

IX. (*continued*).

$\lambda = 2 \cdot 4$

ϕ	(x)	(y)	(t)	(v)
11°	5760	791·7	3111	4120
10¾	5129	670·3	2942	3528
10½	4647	579·9	2794	3134
10¼	4259	508·7	2662	2848
10	3932	450·4	2541	2628
9¾	3651	401·5	2428	2452
9½	3404	359·6	2323	2308
9¼	3184	323·3	2224	2186
9	2986	291·4	2130	2082
8¾	2805	263·2	2040	1991
8½	2639	238·0	1954	1911
8¼	2486	215·4	1871	1840
8	2343	195·0	1791	1776
7	1856	130·7	1497	1575
6	1464	85·9	1234	1430
5	1135	54·1	993	1319
4	852	31·8	771	1230
3	604	16·6	562	1158
2	382	6·9	365	1097
+1	182	1·6	178	1045
0	0	0	0	1000

$\lambda = 2 \cdot 5$

ϕ	(x)	(y)	(t)	(v)
10¼°	4754	586·8	2774	3370
10	4312	507·9	2633	3010
9¾	3952	445·2	2506	2745
9½	3648	393·7	2389	2540
9¼	3385	350·3	2281	2374
9	3154	313·0	2179	2237
8¾	2947	280·7	2083	2122
8½	2759	252·3	1991	2022
8¼	2589	227·2	1904	1936
8	2432	204·7	1820	1859
7	1906	135·3	1515	1625
6	1492	88·1	1245	1461
5	1151	55·1	1000	1339
4	861	32·2	774	1243

$\lambda = 2 \cdot 5$

ϕ	(x)	(y)	(t)	(v)
3°	608	16·7	564	1166
2	384	6·9	366	1101
1	183	1·6	179	1047
0	0	0	0	1000
1	167	1·4	171	959
2	322	5·5	335	923
3	466	11·7	493	891
4	600	19·9	647	863
5	726	29·8	796	837
6	845	41·3	940	814
7	957	54·1	1081	793
8	1064	68·2	1219	773
9	1166	83·4	1354	756
10	1264	99·7	1486	739
11	1357	117·0	1616	724
12	1447	135·3	1744	710
13	1534	154·4	1870	698
14	1617	174·5	1994	686
15	1698	195·4	2117	675
16	1776	217·0	2238	664
17	1852	239·5	2358	655
18	1926	262·8	2477	646
19	1997	286·8	2595	637
20	2067	311·6	2712	629
21	2136	337·1	2829	622
22	2203	363·4	2945	615
23	2268	390·5	3060	608
24	2332	418·3	3176	603
25	2395	447·0	3291	597
26	2456	476·4	3406	592
27	2517	506·6	3521	587
28	2576	537·7	3636	583
29	2635	569·6	3751	578
30	2693	602·4	3867	574
31	2750	636·2	3983	571
32	2807	670·8	4099	568
33	2863	706·4	4216	564
34	2918	743·1	4334	562
35	2973	780·7	4453	559
36	3027	819·4	4572	557

IX. (*continued*).

$\lambda = 2\cdot5$

ϕ	(x)	(y)	(t)	(v)
37°	3081	859·3	4693	555
38	3134	900·3	4815	553
39	3188	942·6	4938	551
40	3240	986·1	5062	549
41	3293	1031	5188	548
42	3345	1077	5316	547
43	3397	1125	5445	546
44	3449	1174	5577	545
45	3501	1225	5710	545
46	3553	1278	5846	544
47	3604	1333	5984	544
48	3656	1389	6124	544
49	3708	1447	6267	544
50	3760	1508	6414	545

$\lambda = 2\cdot6$

ϕ	(x)	(y)	(t)	(v)
10°	4855	592·5	2751	3627
9¾	4354	505·3	2601	3175
9½	3959	438·2	2468	2859
9¼	3632	384·2	2347	2621
9	3354	339·5	2235	2434
8¾	3112	301·7	2131	2283
8½	2897	269·1	2033	2156
8¼	2704	240·8	1940	2048
8	2530	215·8	1852	1955
7¾	2370	193·7	1768	1874
7½	2223	174·0	1687	1802
7¼	2086	156·3	1609	1737
7	1959	140·4	1534	1679
6	1522	90·4	1256	1495
5	1167	56·2	1007	1360
4	869	32·7	778	1257
3	612	16·9	566	1174
2	385	7·0	367	1106
1	183	1·6	179	1049
0	0	0	0	1000

$\lambda = 2\cdot7$

ϕ	(x)	(y)	(t)	(v)
9½°	4383	500·1	2564	3340
9¼	3952	428·9	2425	2966
9	3603	372·9	2300	2695
8¾	3311	327·3	2186	2486
8½	3060	289·1	2080	2320
8¼	2839	256·6	1981	2183
8	2642	228·5	1887	2067
7¾	2465	204·0	1799	1969
7½	2303	182·3	1714	1883
7¼	2154	163·1	1633	1807
7	2017	145·9	1555	1740
6	1553	92·9	1269	1531
5	1185	57·3	1014	1383
4	878	33·1	782	1271
3	616	17·0	568	1183
2	387	7·0	367	1111
1	183	1·6	179	1051
0	0	0	0	1000
1	167	1·4	171	956
2	320	5·4	334	918
3	461	11·6	492	884
4	593	19·6	643	854
5	716	29·3	791	827
6	832	40·5	933	803
7	942	52·9	1072	781
8	1045	66·6	1208	761
9	1144	81·3	1341	743
10	1238	97·0	1471	726
11	1328	113·7	1598	710
12	1414	131·3	1723	696
13	1497	149·7	1847	683
14	1577	168·8	1968	671
15	1654	188·8	2088	660
16	1729	209·5	2207	649
17	1802	230·9	2324	639
18	1872	253·1	2440	630
19	1940	276·0	2555	622
20	2007	299·5	2669	614
21	2072	323·8	2783	606

IX. *(continued)*.

λ = 2·7

φ	(x)	(y)	(t)	(v)
22°	2135	348·8	2896	599
23	2197	374·4	3008	593
24	2258	400·8	3121	587
25	2317	428·0	3233	581
26	2376	455·8	3345	576
27	2433	484·4	3456	571
28	2490	513·8	3568	566
29	2545	543·9	3680	562
30	2600	574·9	3792	558
31	2654	606·7	3905	554
32	2707	639·3	4018	551
33	2760	672·9	4132	548
34	2812	707·3	4246	545
35	2863	742·8	4361	542
36	2915	779·2	4477	540
37	2965	816·6	4594	538
38	3015	855·2	4712	536
39	3065	894·9	4831	534
40	3115	935·7	4952	532
41	3164	977·8	5074	531
42	3213	1021	5197	530
43	3262	1066	5323	529
44	3311	1112	5450	528
45	3359	1160	5579	527
46	3408	1209	5710	527
47	3456	1260	5844	526
48	3504	1313	5980	526
49	3553	1368	6118	526
50	3601	1424	6260	526

λ = 2·8

φ	(x)	(y)	(t)	(v)
9½°	5029	597·2	2691	4191
9¼	4393	492·0	2522	3496
9	3927	417·2	2378	3062
8¾	3559	359·7	2250	2757
8½	3256	313·6	2133	2528

λ = 2·8

φ	(x)	(y)	(t)	(v)
8¼°	2997	275·5	2026	2348
8	2771	243·3	1926	2202
7¾	2572	215·7	1832	2079
7½	2393	191·7	1742	1976
7¼	2230	170·7	1657	1886
7	2081	152·1	1576	1808
6	1588	95·6	1281	1570
5	1203	58·5	1021	1406
4	888	33·6	786	1286
3	621	17·2	570	1191
2	389	7·0	368	1116
1	184	1·6	179	1053
0	0	0	0	1000

λ = 2·9

φ	(x)	(y)	(t)	(v)
9°	4378	480·5	2475	3636
8¾	3882	402·9	2326	3141
8½	3498	344·7	2195	2805
8¼	3186	298·6	2077	2557
8	2922	261·0	1969	2366
7¾	2694	229·4	1868	2212
7½	2493	202·5	1773	2084
7¼	2313	179·2	1684	1976
7	2151	158·9	1599	1884
6	1623	98·5	1294	1612
5	1221	59·7	1028	1431
4	897	34·1	790	1301
3	625	17·4	572	1200
2	390	7·1	369	1121
1	184	1·6	179	1055
0	0	0	0	1000
1	166	1·4	170	953
2	318	5·4	333	912
3	458	11·5	489	877

IX. (*continued*).

$\lambda = 2{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
4°	587	19·4	640	846
5	708	28·8	785	817
6	821	39·7	926	792
7	927	51·8	1064	770
8	1028	65·1	1197	749
9	1123	79·3	1328	730
10	1214	94·5	1455	713
11	1301	110·6	1581	697
12	1384	127·5	1704	683
13	1464	145·1	1824	669
14	1540	163·6	1943	657
15	1614	182·7	2061	645
16	1686	202·5	2177	635
17	1755	223·0	2291	625
18	1822	244·2	2405	616
19	1887	266·0	2517	607
20	1951	288·5	2629	599
21	2013	311·6	2740	591
22	2073	335·3	2850	584
23	2132	359·8	2960	578
24	2189	384·8	3069	572
25	2246	410·6	3178	566
26	2302	437·0	3287	561
27	2356	464·1	3396	556
28	2409	491·9	3505	551
29	2462	520·4	3614	547
30	2514	549·7	3723	543
31	2565	579·8	3833	539
32	2615	610·7	3943	536
33	2665	642·4	4053	532
34	2714	674·9	4164	529
35	2763	708·4	4276	527
36	2811	742·8	4389	524
37	2859	778·1	4502	522
38	2906	814·5	4617	520
39	2953	851·8	4733	518

$\lambda = 2{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
40°	3000	890·3	4850	516
41	3047	930·0	4968	515
42	3093	970·8	5088	514
43	3139	1013	5210	513
44	3185	1056	5333	512
45	3230	1101	5458	511
46	3276	1148	5586	510
47	3321	1196	5715	510
48	3367	1245	5847	510
49	3412	1296	5981	510
50	3457	1350	6118	510

$\lambda = 3{\cdot}0$

ϕ	(x)	(y)	(t)	(v)
9°	5106	585·1	2606	4735
8¾	4337	465·0	2421	3748
8½	3816	385·9	2269	3198
8¼	3421	327·7	2136	2835
8	3103	282·3	2017	2573
7¾	2837	245·5	1909	2373
7½	2608	214·9	1808	2213
7¼	2407	188·9	1713	2081
7	2228	166·5	1624	1970
6	1661	101·6	1308	1657
5	1241	61·0	1036	1457
4	907	34·6	794	1316
3	629	17·5	573	1209
2	392	7·1	370	1126
1	184	1·6	179	1057
0	0	0	0	1000

IX. (*continued*).

$\lambda = 3{\cdot}1$				
ϕ	(x)	(y)	(t)	(v)
8½°	4263	445·5	2361	3823
8¼	3727	366·5	2207	3230
8	3327	309·3	2073	2849
7¾	3008	265·1	1954	2575
7½	2742	229·5	1846	2368
7¼	2514	200·0	1745	2204
7	2315	175·1	1651	2070
6¾	2138	153·8	1563	1958
6½	1979	135·3	1479	1862
6¼	1835	119·2	1399	1779
6	1702	105·0	1322	1707
5	1262	62·3	1044	1485
4	917	35·1	798	1332
3	634	17·7	575	1219
2	394	7·2	371	1131
1	185	1·6	180	1059
0	0	0	0	1000
1	166	1·4	170	950
2	316	5·3	332	907
3	454	11·3	487	870
4	581	19·1	636	837
5	699	28·4	780	808
6	809	39·0	920	782
7	913	50·8	1055	759
8	1011	63·6	1187	738
9	1103	77·4	1315	718
10	1191	92·1	1441	701
11	1275	107·6	1564	685
12	1355	123·9	1684	670
13	1432	140·9	1803	657
14	1505	158·6	1920	644
15	1577	177·0	2035	632
16	1645	196·0	2148	621
17	1711	215·7	2261	612
18	1776	235·9	2372	602

$\lambda = 3{\cdot}1$				
ϕ	(x)	(y)	(t)	(v)
19°	1838	256·8	2482	593
20	1899	278·2	2591	585
21	1958	300·3	2699	578
22	2015	323·0	2807	571
23	2071	346·2	2914	564
24	2126	370·1	3021	558
25	2180	394·6	3127	552
26	2233	419·7	3233	547
27	2284	445·5	3340	542
28	2335	471·9	3446	537
29	2385	499·1	3552	533
30	2435	526·9	3659	529
31	2483	555·4	3765	525
32	2531	584·7	3872	521
33	2578	614·7	3980	518
34	2625	645·6	4088	515
35	2671	677·3	4197	513
36	2716	709·8	4307	510
37	2761	743·2	4417	508
38	2806	777·6	4529	506
39	2851	813·0	4641	504
40	2895	849·3	4755	502
41	2939	886·8	4870	501
42	2982	925·4	4987	499
43	3026	965·2	5105	498
44	3069	1006	5224	497
45	3112	1049	5346	496
46	3155	1092	5469	496
47	3198	1137	5595	495
48	3240	1184	5723	495
49	3283	1232	5853	495
50	3326	1282	5986	495

IX. (*continued*).

$\lambda = 3{\cdot}2$

ϕ	(x)	(y)	(t)	(v)
8¼°	4158	422·1	2295	3852
8	3617	344·8	2140	3233
7¾	3218	289·5	2007	2840
7½	2901	247·1	1888	2562
7¼	2638	213·1	1780	2353
7	2414	185·0	1680	2187
6¾	2218	161·4	1587	2052
6½	2045	141·2	1500	1940
6¼	1889	123·8	1417	1844
6	1747	108·6	1338	1761
5	1283	63·7	1052	1514
4	927	35·6	802	1349
3	639	17·9	577	1229
2	395	7·2	371	1136
1	185	1·6	180	1061
0	0	0	0	1000

$\lambda = 3{\cdot}3$

ϕ	(x)	(y)	(t)	(v)
8°	4021	395·4	2223	3834
7¾	3487	321·4	2069	3207
7½	3094	268·9	1937	2813
7¼	2784	228·6	1819	2535
7	2527	196·5	1713	2326
6¾	2308	170·0	1614	2162
6½	2116	147·8	1522	2028
6¼	1947	128·9	1436	1916
6	1795	112·5	1354	1821
5	1306	65·2	1061	1546
4	938	36·2	807	1367
3	643	18·0	580	1238
2	397	7·2	372	1141
1	186	1·7	180	1063
0	0	0	0	1000

$\lambda = 3{\cdot}3$

ϕ	(x)	(y)	(t)	(v)
1°	165	1·4	170	947
2	314	5·3	331	902
3	450	11·2	485	863
4	575	18·8	633	829
5	691	27·9	776	799
6	798	38·3	913	772
7	899	49·8	1047	748
8	994	62·2	1177	727
9	1084	75·6	1303	707
10	1169	89·9	1427	689
11	1250	104·9	1548	673
12	1327	120·6	1666	658
13	1401	137·0	1783	644
14	1472	154·0	1897	632
15	1540	171·7	2010	620
16	1606	190·0	2121	609
17	1670	208·8	2231	599
18	1731	228·2	2340	589
19	1791	248·2	2448	581
20	1849	268·8	2554	573
21	1906	289·9	2660	565
22	1961	311·6	2766	558
23	2014	333·8	2870	551
24	2067	356·6	2975	545
25	2118	380·0	3078	539
26	2168	403·9	3182	534
27	2218	428·5	3286	529
28	2266	453·7	3389	524
29	2314	479·5	3493	520
30	2361	506·0	3597	516
31	2407	533·1	3701	512
32	2452	561·0	3805	508
33	2497	589·5	3910	505
34	2541	618·8	4016	502
35	2585	648·9	4122	499
36	2628	679·8	4228	497

IX. (*continued*).

$\lambda = 3{\cdot}4$

ϕ	(x)	(y)	(t)	(v)
7¾°	3856	366·1	2145	3769
7½	3340	296·9	1994	3155
7¼	2959	247·7	1864	2768
7	2658	210·0	1749	2496
6¾	2409	180·0	1644	2290
6½	2197	155·3	1547	2129
6¼	2012	134·5	1456	1997
6	1847	116·9	1371	1887
5	1330	66·8	1070	1579
4	949	36·7	811	1385
3	648	18·2	582	1248
2	399	7·3	373	1146
1	186	1·7	180	1065
0	0	0	0	1000

$\lambda = 3{\cdot}5$

ϕ	(x)	(y)	(t)	(v)
7¾°	4428	437·1	2246	4789
7½	3669	335·3	2063	3664
7¼	3179	271·8	1915	3080
7	2816	226·4	1789	2709
6¾	2527	191·6	1676	2445
6½	2288	163·7	1573	2246
6¼	2083	140·7	1478	2089
6	1904	121·7	1389	1961
5	1355	68·5	1079	1614
4	961	37·3	816	1403
3	653	18·4	584	1259
2	401	7·3	374	1151
1	186	1·6	180	1067
0	0	0	0	1000
1	165	1·4	170	944
2	312	5·3	330	897
3	446	11·1	483	856

$\lambda = 3{\cdot}5$

ϕ	(x)	(y)	(t)	(v)
4°	569	18·6	630	821
5	682	27·5	771	790
6	788	37·6	907	763
7	886	48·8	1039	738
8	978	60·9	1167	716
9	1065	73·9	1292	696
10	1148	87·7	1413	678
11	1226	102·3	1532	662
12	1301	117·4	1649	647
13	1372	133·3	1763	633
14	1441	149·7	1875	620
15	1507	166·7	1986	608
16	1570	184·3	2095	597
17	1631	202·4	2203	587
18	1690	221·1	2310	578
19	1747	240·3	2415	569
20	1803	260·0	2520	561
21	1857	280·2	2623	553
22	1910	301·0	2726	546
23	1961	322·2	2829	539
24	2012	344·0	2931	533
25	2061	366·4	3033	527
26	2109	389·3	3134	522
27	2156	412·8	3235	517
28	2202	436·8	3336	512
29	2247	461·4	3438	508
30	2292	486·7	3539	504
31	2336	512·6	3641	500
32	2379	539·1	3743	496
33	2422	566·3	3845	493
34	2464	594·2	3948	490
35	2506	622·9	4051	487
36	2547	652·3	4156	485

IX. (*continued*).

$\lambda = 3{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
7°	3254	273·4	1890	3375
6¾	2832	222·4	1753	2882
6½	2511	185·1	1634	2556
6¼	2253	156·2	1527	2320
6	2036	133·0	1430	2140
5¾	1850	113·8	1339	1996
5½	1687	97·7	1254	1877
5¼	1541	84·0	1174	1778
5	1410	72·2	1098	1693
4½	1180	53·1	956	1553
4	985	38·6	825	1444
3½	814	27·4	703	1354
3	663	18·8	588	1280
2½	527	12·3	479	1217
2	404	7·4	375	1162
1½	291	3·9	276	1114
1	187	1·7	181	1072
0½	90	0·4	89	1034
0	0	0	0	1000

$\lambda = 3{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
6½°	2827	216·1	1711	3043
6¼	2476	176·9	1586	2650
6	2202	147·4	1476	2379
5¾	1976	124·2	1377	2176
5½	1785	105·3	1285	2018
5¼	1618	89·7	1200	1890
5	1471	76·4	1119	1784
4½	1220	55·5	971	1616
4	1011	40·0	835	1488
3½	831	28·2	710	1386
3	674	19·2	593	1303
2½	534	12·5	482	1233
2	407	7·5	377	1173

$\lambda = 3{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
1½°	293	4·0	277	1121
1	188	1·7	181	1076
0½	90	0·4	89	1036
0	0	0	0	1000
1	164	1·4	169	938
2	309	5·2	328	887
3	439	10·9	479	844
4	558	18·1	624	806
5	667	26·7	762	774
6	768	36·3	895	745
7	861	47·0	1024	720
8	949	58·5	1148	697
9	1031	70·8	1269	676
10	1109	83·8	1387	658
11	1182	97·4	1503	641
12	1252	111·6	1615	626
13	1319	126·4	1726	612
14	1383	141·7	1834	599
15	1444	157·6	1941	587
16	1503	173·9	2047	576
17	1560	190·7	2150	565
18	1615	208·0	2253	556
19	1668	225·8	2354	547
20	1719	244·0	2455	539
21	1769	262·6	2555	531
22	1818	281·8	2654	524
23	1865	301·4	2752	517
24	1911	321·4	2850	511
25	1956	342·0	2948	505
26	2000	363·0	3045	500
27	2043	384·6	3142	495
28	2086	406·6	3239	490
29	2127	429·2	3336	486
30	2168	452·3	3433	482
31	2208	476·0	3530	478
32	2248	500·3	3627	475
33	2287	525·1	3725	471
34	2326	550·6	3823	468
35	2364	576·8	3922	465
36	2401	603·6	4022	463

IX. (*continued*).

$\lambda = 4 \cdot 1$				
ϕ	(x)	(y)	(t)	(v)
6¼°	2797	207·3	1663	3179
6	2421	166·9	1534	2721
5¾	2135	137·4	1422	2417
5½	1904	114·6	1321	2196
5¼	1710	96·4	1228	2027
5	1542	81·4	1143	1891
4¾	1396	68·8	1062	1780
4½	1265	58·2	987	1686
4	1039	41·4	846	1536
3½	849	29·0	717	1419
3	685	19·6	597	1326
2½	540	12·7	485	1249
2	411	7·6	379	1184
1½	295	4·0	278	1129
1	188	1·7	181	1080
0½	91	0·4	89	1038
0	0	0	0	1000

$\lambda = 4 \cdot 3$				
ϕ	(x)	(y)	(t)	(v)
6°	2737	195·8	1607	3272
5¾	2344	155·3	1476	2760
5½	2052	126·5	1362	2432
5¼	1819	104·5	1261	2198
5	1625	87·1	1169	2021
4¾	1460	73·0	1083	1881
4½	1315	61·3	1004	1766
4¼	1186	51·4	929	1670
4	1070	43·1	857	1589
3½	869	29·8	724	1456
3	697	20·1	602	1351
2½	548	12·9	488	1267
2	415	7·7	380	1196

$\lambda = 4 \cdot 3$				
ϕ	(x)	(y)	(t)	(v)
1½°	297	4·1	279	1136
1	189	1·7	182	1085
0½	91	0·4	089	1040
0	0	0	0	1000
1	163	1·4	169	933
2	305	5·1	326	877
3	433	10·6	475	831
4	548	17·6	617	792
5	652	25·9	753	758
6	749	35·1	883	728
7	838	45·3	1009	702
8	921	56·2	1130	679
9	999	67·9	1248	658
10	1073	80·2	1363	639
11	1142	93·0	1475	622
12	1208	106·4	1584	606
13	1270	120·3	1691	592
14	1330	134·6	1797	579
15	1388	149·5	1900	567
16	1443	164·7	2002	556
17	1496	180·4	2102	546
18	1547	196·5	2201	536
19	1596	213·1	2299	528
20	1644	230·0	2396	519
21	1690	247·3	2492	512
22	1736	265·1	2587	505
23	1779	283·3	2682	498
24	1822	301·9	2776	492
25	1864	320·9	2870	486
26	1905	340·3	2963	481
27	1944	360·2	3057	476
28	1984	380·6	3150	471
29	2022	401·4	3243	467
30	2060	422·7	3336	463

IX. (*continued*).

$\lambda = 4·5$				
ϕ	(x)	(y)	(t)	(v)
5¾°	2641	181·4	1544	3310
5½	2244	142·2	1412	2764
5¼	1953	114·8	1299	2422
5	1722	94·1	1198	2182
4¾	1532	77·8	1107	2002
4½	1370	64·7	1022	1860
4¼	1228	53·9	943	1744
4	1103	44·9	869	1648
3¾	991	37·2	799	1567
3½	889	30·8	732	1495
3	709	20·5	607	1378
2½	554	13·1	491	1285
2	419	7·8	382	1208
1½	299	4·1	279	1144
1	190	1·7	182	1089
0½	91	0·4	89	1042
0	0	0	0	1000

$\lambda = 4·7$				
ϕ	(x)	(y)	(t)	(v)
5½°	2515	165·0	1474	3286
5¼	2125	128·3	1343	2733
5	1841	102·7	1232	2389
4¾	1618	83·6	1133	2149
4½	1433	68·7	1043	1969
4¼	1276	56·7	960	1828
4	1140	46·8	882	1714
3¾	1019	38·6	809	1618
3½	910	31·8	740	1537
3¼	812	26·0	675	1467
3	722	21·0	612	1406
2½	562	13·3	494	1304
2	423	7·9	384	1221

$\lambda = 4·7$				
ϕ	(x)	(y)	(t)	(v)
1½°	301	4·1	280	1152
1	191	1·7	182	1094
0½	91	0·4	89	1044
0	0	0	0	1000
1	162	1·4	168	927
2	302	5·0	324	868
3	426	10·4	472	820
4	538	17·2	611	779
5	639	25·1	745	743
6	731	34·0	872	713
7	816	43·7	995	686
8	896	54·2	1114	662
9	970	65·2	1228	641
10	1039	76·9	1340	622
11	1105	89·0	1449	605
12	1167	101·7	1555	589
13	1226	114·8	1659	575
14	1282	128·3	1761	562
15	1336	142·2	1861	550
16	1388	156·5	1960	539
17	1437	171·2	2057	528
18	1485	186·3	2153	519
19	1531	201·7	2247	510
20	1576	217·6	2341	502
21	1619	233·7	2434	494
22	1661	250·3	2526	487
23	1702	267·2	2617	481
24	1742	284·5	2708	475
25	1781	302·2	2799	469
26	1819	320·3	2889	464
27	1856	338·8	2979	459
28	1892	357·7	3068	454
29	1928	377·1	3158	450
30	1963	396·8	3248	446

IX. (*continued*).

$\lambda = 4·9$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
5¼°	2362	147·2	1399	3205
5	1991	113·9	1271	2668
4¾	1720	90·7	1162	2335
4½	1506	73·4	1065	2101
4¼	1330	59·9	977	1926
4	1180	49·1	896	1788
3¾	1049	40·2	820	1677
3½	934	32·9	749	1584
3¼	830	26·8	682	1505
3	735	21·6	617	1436
2½	570	13·6	497	1323
2	427	8·0	386	1234
1½	303	4·2	281	1160
1	191	1·7	183	1098
0½	91	0·4	89	1046
0	0	0	0	1000

$\lambda = 5·1$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
5°	2192	129·0	1319	3076
4¾	1848	99·6	1196	2578
4½	1594	79·0	1090	2263
4¼	1393	63·6	996	2041
4	1226	51·5	911	1874
3¾	1084	41·9	832	1742
3½	959	34·0	758	1634
3¼	849	27·5	689	1545
3	750	22·1	623	1468
2½	578	13·8	501	1344
2	432	8·1	388	1247
1½	305	4·2	282	1169
1	192	1·7	183	1103
0½	92	0·4	89	1048
0	0	0	0	1000
1	161	1·4	167	921
2	299	5·0	323	859
3	420	10·2	468	808

$\lambda = 5·1$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
4°	528	16·8	606	766
5	625	24·5	737	729
6	714	33·0	862	698
7	796	42·3	982	671
8	872	52·3	1098	647
9	942	62·8	1210	625
10	1008	73·9	1319	606
11	1071	85·4	1425	589
12	1129	97·4	1529	573
13	1185	109·8	1630	559
14	1238	122·5	1729	546
15	1289	135·6	1826	533
16	1338	149·1	1922	522
17	1384	163·0	2016	512
18	1429	177·1	2109	503
19	1473	191·6	2201	494
20	1515	206·5	2291	486
21	1555	221·7	2381	479
22	1595	237·2	2470	472
23	1633	253·0	2559	465
24	1670	269·2	2647	459

$\lambda = 5·3$

ϕ	(*x*)	(*y*)	(*t*)	(*v*)
5°	2485	151·8	1380	3756
4¾	2011	111·3	1236	2919
4½	1698	85·9	1119	2470
4¼	1464	67·9	1018	2180
4	1276	54·4	927	1973
3¾	1120	43·8	845	1815
3½	986	35·3	768	1690
3¼	869	28·4	697	1588
3	765	22·7	629	1502
2½	586	14·1	504	1366
2	436	8·2	390	1261
1½	307	4·2	283	1177
1	193	1·7	183	1108
0½	91	0·4	89	1050
0	0	0	0	1000

IX. (*continued*).

$\lambda = 5·5$

ϕ	(x)	(y)	(t)	(v)
4¾°	2238	127·8	1287	3443
4½	1828	94·6	1153	2746
4¼	1547	73·1	1042	2352
4	1333	57·7	945	2089
3¾	1161	46·0	858	1899
3½	1016	36·7	778	1753
3¼	891	29·4	704	1636
3	781	23·4	635	1539
2½	595	14·4	508	1389
2	440	8·3	391	1275
1½	309	4·3	284	1186
1	194	1·8	184	1113
0½	92	0·4	90	1052
0	0	0	0	1000
1	160	1·4	167	916
2	296	4·9	321	850
3	414	10·0	465	798
4	519	16·4	600	754
5	613	23·8	729	716
6	699	32·0	852	684
7	777	41·0	969	657
8	850	50·5	1083	632
9	917	60·6	1192	611
10	980	71·1	1299	591
11	1039	82·1	1402	574
12	1095	93·4	1503	558
13	1148	105·2	1601	544
14	1198	117·3	1698	531
15	1247	129·7	1792	519
16	1293	142·5	1885	508
17	1337	155·5	1977	498
18	1379	168·9	2067	488
19	1420	182·6	2156	480
20	1459	196·5	2244	472
21	1497	210·8	2331	464
22	1535	225·4	2418	457
23	1571	240·3	2503	451
24	1606	255·5	2589	445

$\lambda = 5·7$

ϕ	(x)	(y)	(t)	(v)
4½°	2001	106·4	1193	3143
4¼	1650	79·5	1069	2572
4	1401	61·5	965	2229
3¾	1207	48·4	873	1995
3½	1049	38·3	790	1822
3¼	915	30·4	713	1688
3	799	24·1	642	1579
2¾	696	18·9	575	1489
2½	604	14·7	511	1413
2	445	8·4	394	1290
1½	311	4·3	285	1194
1	195	1·8	184	1118
0½	92	0·4	90	1054
0	0	0	0	1000

$\lambda = 5·9$

ϕ	(x)	(y)	(t)	(v)
4½°	2247	123·6	1244	3782
4¼	1780	87·7	1101	2867
4	1480	66·1	987	2402
3¾	1259	51·1	889	2108
3½	1085	40·1	801	1901
3¼	940	31·5	722	1745
3	817	24·8	648	1622
2¾	709	19·4	580	1521
2½	614	15·0	515	1438
2	450	8·6	395	1305
1½	313	4·4	286	1203
1	195	1·8	185	1122
0½	92	0·4	90	1056
0	0	0	0	1000
1	159	1·3	166	911
2	293	4·8	319	842
3	408	9·8	461	787
4	510	16·0	595	742
5	601	23·2	721	704
6	683	31·1	842	671

IX. (*continued*).

$\lambda = 5{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
7°	759	39·7	957	643
8	828	48·8	1068	619
9	893	58·5	1176	597
10	953	68·5	1279	577
11	1009	79·0	1380	560
12	1062	89·8	1479	544
13	1113	101·0	1575	530
14	1161	112·4	1668	517
15	1206	124·2	1761	505
16	1250	136·3	1851	494
17	1291	148·7	1940	484
18	1332	161·3	2028	475
19	1370	174·3	2115	466
20	1408	187·5	2200	458
21	1444	201·0	2285	451
22	1479	214·7	2369	444
23	1513	228·8	2452	438
24	1546	243·2	2535	432

$\lambda = 6{\cdot}1$

ϕ	(x)	(y)	(t)	(v)
4¼°	1949	98·7	1140	3296
4	1574	71·7	1012	2622
3¾	1319	54·3	906	2242
3½	1125	42·0	814	1990
3¼	968	32·8	731	1808
3	836	25·6	655	1668
2¾	723	19·9	585	1556
2½	624	15·3	519	1465
2	455	8·7	398	1321
1½	316	4·4	287	1213
1	196	1·8	185	1127
0½	92	0·4	90	1058
0	0	0	0	1000

$\lambda = 6{\cdot}3$

ϕ	(x)	(y)	(t)	(v)
4°	1693	78·8	1041	2916
3¾	1388	58·1	925	2406
3½	1170	44·2	827	2094
3¼	998	34·1	741	1879
3	857	26·4	662	1719
2¾	738	20·4	590	1594
2½	634	15·7	523	1493
2	460	8·8	400	1337
1½	318	4·4	288	1222
1	197	1·8	186	1132
0½	92	0·4	90	1060
0	0	0	0	1000
1	158	1·3	166	906
2	289	4·7	318	834
3	402	9·7	458	777
4	501	15·7	590	731
5	590	22·6	714	692
6	669	30·3	833	659
7	742	38·5	946	631
8	808	47·3	1055	606
9	870	56·5	1160	584
10	928	66·2	1261	565
11	982	76·2	1360	547
12	1033	86·5	1456	532
13	1081	97·1	1550	517
14	1126	108·0	1642	504
15	1169	119·2	1731	493
16	1211	130·7	1820	482
17	1250	142·5	1906	472
18	1289	154·5	1992	463
19	1325	166·8	2076	454
20	1361	179·3	2160	446
21	1395	192·1	2242	439
22	1428	205·1	2324	432
23	1460	218·4	2405	426
24	1491	232·0	2486	419

IX. (*continued*).

$\lambda = 6{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
4°	2073	102·5	1119	4019
3¾	1574	68·5	972	2880
3½	1279	49·8	859	2362
3¼	1068	37·3	763	2049
3	905	28·4	678	1836
2¾	770	21·6	602	1678
2½	657	16·4	531	1554
2¼	558	12·3	466	1455
2	471	9·1	404	1372
1½	323	4·5	290	1242
1	199	1·8	186	1143
0½	93	0·4	90	1064
0	0	0	0	1000

$\lambda = 7{\cdot}1$

ϕ	(x)	(y)	(t)	(v)
3¾°	1887	86·7	1039	3826
3½	1431	57·7	898	2769
3¼	1157	41·5	789	2278
3	961	30·7	696	1981
2¾	807	23·0	614	1776
2½	682	17·2	540	1624
2¼	575	12·8	472	1505
2	482	9·4	408	1409
1½	327	4·6	292	1262
1	201	1·8	187	1153
0½	93	0·4	90	1068
0	0	0	0	1000
1	156	1·3	165	895
2	284	4·6	314	818
3	392	9·3	452	758
4	486	15·0	580	710
5	569	21·6	701	670
6	643	28·7	815	637
7°	711	36·4	924	608
8	772	44·5	1029	583
9	829	53·0	1130	561
10	882	61·9	1227	542
11	932	71·1	1322	524
12	978	80·5	1414	509
13	1022	90·3	1503	494
14	1064	100·2	1591	482
15	1103	110·5	1677	470
16	1141	120·9	1761	460
17	1177	131·6	1844	450
18	1212	142·5	1925	441
19	1245	153·6	2006	432
20	1277	164·9	2085	425
21	1308	176·5	2163	418
22	1338	188·3	2241	411
23	1367	200·3	2318	405
24	1395	212·6	2394	399

$\lambda = 7{\cdot}5$

ϕ	(x)	(y)	(t)	(v)
3½°	1667	70·4	951	3499
3¼	1274	47·0	820	2606
3	1029	33·6	717	2167
2¾	850	24·6	628	1895
2½	710	18·2	550	1704
2¼	594	13·4	479	1562
2	495	9·7	413	1450
1½	333	4·7	294	1284
1	202	1·9	188	1164
0½	94	0·4	90	1073
0	0	0	0	1000

IX. (*continued*).

$\lambda = 7{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
3¼°	1442	55·5	860	3131
3	1115	37·4	741	2418
2¾	901	26·6	644	2040
2½	741	19·3	561	1798
2¼	614	14·0	486	1625
2	508	10·0	418	1495
1½	338	4·8	297	1307
1	204	1·9	189	1175
0½	94	0·4	91	1077
0	0	0	0	1000
1	154	1·3	164	885
2	278	4·5	311	803
3	382	9·0	446	741
4	471	14·4	571	691
5	549	20·6	688	650
6	619	27·3	799	616
7	682	34·5	905	587
8	740	42·1	1006	562
9	793	50·0	1103	540
10	842	58·2	1197	521
11	888	66·7	1288	504
12	931	75·4	1376	488
13	971	84·3	1462	474
14	1009	93·5	1546	462
15	1046	102·9	1628	450
16	1080	112·5	1709	440
17	1113	122·3	1788	430
18	1145	132·3	1866	421
19	1175	142·4	1943	313
20	1205	152·8	2019	406
21	1233	163·4	2094	399
22	1260	174·1	2168	392
23	1287	185·1	2241	386
24	1312	196·2	2315	381

$\lambda = 8{\cdot}3$

ϕ	(x)	(y)	(t)	(v)
3°	1230	42·5	771	2781
2¾	962	29·0	663	2226
2½	777	20·5	573	1909
2¼	636	14·7	494	1697
2	522	10·4	424	1544
1¾	426	7·3	359	1425
1½	344	4·9	299	1331
1	206	1·9	189	1187
0½	94	0·4	91	1081
0	0	0	0	1000

$\lambda = 8{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
3°	1401	50·4	809	3399
2¾	1039	32·1	684	2473
2½	820	22·0	586	2043
2¼	662	15·4	503	1780
2	538	10·8	430	1598
1¾	436	7·5	363	1462
1½	349	5·0	301	1356
1	208	1·9	190	1199
0½	95	0·4	91	1086
0	0	0	0	1000
1	153	1·3	163	876
2	273	4·4	308	789
3	373	8·7	440	724
4	458	13·9	562	673
5	532	19·7	676	632
6	598	26·0	784	597

IX. (*continued*).

$\lambda = 8{\cdot}7$

ϕ	(x)	(y)	(t)	(v)
7°	657	32·8	886	568
8	711	39·9	984	543
9	760	47·3	1078	522
10	806	54·9	1169	502
11	848	62·8	1256	486
12	888	70·9	1342	470
13	926	79·2	1424	456
14	961	87·7	1505	444
15	995	96·4	1584	433
16	1027	105·2	1662	423
17	1057	114·3	1738	413
18	1086	123·5	1813	405
19	1114	132·8	1887	397
20	1141	142·4	1959	389
21	1167	152·1	2031	383
22	1193	162·0	2102	376
23	1217	172·1	2173	370
24	1240	182·3	2243	365

$\lambda = 9{\cdot}1$

ϕ	(x)	(y)	(t)	(v)
2¾°	1141	36·3	710	2827
2½	870	23·8	601	2210
2¼	690	16·3	513	1876
2	555	11·3	436	1658
1¾	446	7·7	367	1502
1½	356	5·2	304	1383
1	210	2·0	191	1211
0½	95	0·4	91	1090
0	0	0	0	1000

$\lambda = 9{\cdot}5$

ϕ	(x)	(y)	(t)	(v)
2¾°	1287	42·5	742	3394
2½	932	26·1	618	2426
2¼	723	17·3	523	1989
2	573	11·8	442	1725
1¾	457	8·0	371	1545
1½	362	5·3	307	1411
1	212	2·0	192	1223
0½	95	0·4	91	1095
0	0	0	0	1000
1	151	1·3	162	867
2	268	4·3	305	776
3	364	8·4	434	708
4	445	13·4	554	657
5	515	18·9	665	615
6	578	24·9	770	580
7	633	31·3	869	551
8	684	37·9	964	527
9	731	44·8	1055	505
10	773	52·0	1142	486
11	813	59·4	1227	469
12	850	66·9	1309	454
13	885	74·7	1389	441
14	918	82·6	1467	428
15	949	90·6	1544	418
16	979	98·9	1618	407
17	1007	107·3	1692	398
18	1034	115·8	1764	390
19	1060	124·5	1835	382
20	1085	133·3	1905	375
21	1109	142·3	1974	368
22	1133	151·5	2042	362
23	1155	160·8	2110	356
24	1177	170·3	2177	351

IX. (*continued*).

$\lambda = 9{\cdot}9$

ϕ	(x)	(y)	(t)	(v)
$2\frac{1}{2}°$	1011	29·0	639	2722
$2\frac{1}{4}$	761	18·6	534	2125
2	594	12·4	449	1802
$1\frac{3}{4}$	469	8·3	375	1592
$1\frac{1}{2}$	369	5·4	309	1442
$1\frac{1}{4}$	286	3·4	249	1327
1	214	2·0	193	1236
$0\frac{3}{4}$	152	1·0	141	1162
$0\frac{1}{2}$	96	0·4	91	1100
0	0	0	0	1000

$\lambda = 10{\cdot}3$

ϕ	(x)	(y)	(t)	(v)
$2\frac{1}{2}°$	1118	33·1	663	3161
$2\frac{1}{4}$	805	20·0	547	2293
2	617	13·0	457	1889
$1\frac{3}{4}$	482	8·6	380	1644
$1\frac{1}{2}$	376	5·6	312	1474
$1\frac{1}{4}$	290	3·5	251	1348
1	216	2·0	194	1250
$0\frac{3}{4}$	153	1·1	141	1170
$0\frac{1}{2}$	96	0·4	92	1104
0	0	0	0	1000

$\lambda = 10{\cdot}3$

ϕ	(x)	(y)	(t)	(v)
1°	149	1·2	161	857
2	263	4·2	302	763
3	355	8·2	429	694
4	433	12·9	546	642
5	500	18·2	654	599
6	559	23·9	756	565
7	612	29·9	853	536
8	660	36·1	945	511
9	703	42·7	1033	490
10	744	49·4	1118	471
11	781	56·3	1200	454
12	816	63·4	1280	440
13	849	70·6	1357	426
14	879	78·0	1432	414
15	909	85·6	1506	403
16	936	93·3	1578	394
17	963	101·1	1649	385
18	988	109·0	1719	376
19	1012	117·1	1787	369
20	1035	125·4	1855	362
21	1058	133·8	1922	355
22	1079	142·3	1988	349
23	1100	150·9	2053	344
24	1121	159·8	2118	338

X.

$\{1000 \div v\}^2$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											—
10	100·00	98·03	96·12	94·26	92·46	90·70	89·00	87·34	85·73	84·17	1·76
11	82·64	81·16	79·72	78·31	76·95	75·61	74·32	73·05	71·82	70·62	1·33
12	69·44	68·30	67·19	66·10	65·04	64·00	62·99	62·00	61·04	60·09	1·04
13	59·17	58·27	57·39	56·53	55·69	54·87	54·07	53·28	52·51	51·76	·83
14	51·02	50·30	49·59	48·90	48·23	47·56	46·91	46·28	45·65	45·04	66
15	44·44	43·86	43·28	42·72	42·17	41·62	41·09	40·57	40·06	39·56	54
16	39·06	38·58	38·10	37·64	37·18	36·73	36·29	35·86	35·43	35·01	45
17	34·60	34·20	33·80	33·41	33·03	32·65	32·28	31·92	31·56	31·21	38
18	30·86	30·52	30·19	29·86	29·54	29·22	28·91	28·60	28·29	28·00	32
19	27·70	27·41	27·13	26·85	26·57	26·30	26·03	25·77	25·51	25·25	27
20	25·00	24·75	24·51	24·27	24·03	23·80	23·57	23·34	23·11	22·89	23
21	22·68	22·46	22·25	22·04	21·84	21·63	21·43	21·24	21·04	20·85	20
22	20·66	20·48	20·29	20·11	19·93	19·75	19·58	19·41	19·24	19·07	18
23	18·90	18·74	18·58	18·42	18·26	18·11	17·96	17·80	17·65	17·51	15
24	17·36	17·22	17·08	16·94	16·80	16·66	16·53	16·39	16·26	16·13	14
25	16·00	15·87	15·75	15·62	15·50	15·38	15·26	15·14	15·02	14·91	12
26	14·79	14·68	14·57	14·46	14·35	14·24	14·13	14·03	13·92	13·82	11
27	13·72	13·62	13·52	13·42	13·32	13·22	13·13	13·03	12·94	12·85	10
28	1 2·755	2·664	2·575	2·486	2·398	2·311	2·226	2·140	2·056	1·973	87
29	1·891	1·809	1·728	1·648	1·569	1·491	1·413	1·337	1·261	1·186	78
30	1·111	1·037	0·964	0·892	0·821	0·750	0·680	0·610	0·541	0·473	71
31	1 0·406	0·339	0·273	0·207	0·142	0·078	0·014	*9·951	*9·889	*9·827	64
32	9·766	9·705	9·645	9·585	9·526	9·467	9·409	9·352	9·295	9·239	59
33	9·183	9·127	9·072	9·018	8·964	8·911	8·858	8·805	8·753	8·702	53
34	8·651	8·600	8·550	8·500	8·451	8·402	8·353	8·305	8·257	8·210	49
35	8·163	8·117	8·071	8·025	7·980	7·935	7·890	7·846	7·803	7·759	45
36	7·716	7·673	7·631	7·589	7·547	7·506	7·465	7·425	7·384	7·344	41
37	7·305	7·265	7·226	7·188	7·149	7·111	7·073	7·036	6·999	6·962	38
38	6·925	6·889	6·853	6·817	6·782	6·746	6·711	6·677	6·643	6·608	35
39	6·575	6·541	6·508	6·475	6·442	6·409	6·377	6·345	6·313	6·281	33
40	6·250	6·219	6·188	6·157	6·127	6·097	6·067	6·037	6·007	5·978	30
41	5·949	5·920	5·891	5·863	5·834	5·806	5·778	5·751	5·723	5·696	28
42	5·669	5·642	5·615	5·589	5·562	5·536	5·510	5·485	5·459	5·434	26
43	5·408	5·383	5·358	5·334	5·309	5·285	5·260	5·236	5·213	5·189	24
44	5·165	5·142	5·119	5·096	5·073	5·050	5·027	5·005	4·982	4·960	23
45	4·938	4·916	4·895	4·873	4·852	4·830	4·809	4·788	4·767	4·747	21
46	4·726	4·705	4·685	4·665	4·645	4·625	4·605	4·585	4·566	4·546	20
47	4·527	4·508	4·489	4·470	4·451	4·432	4·414	4·395	4·377	4·358	19
48	4·340	4·322	4·304	4·287	4·269	4·251	4·234	4·216	4·199	4·182	18

X. (*continued*).

$\{1000 \div v\}^2$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											--
49	4·165	4·148	4·131	4·114	4·098	4·081	4·065	4·048	4·032	4·016	17
50	4·000	3·984	3·968	3·952	3·937	3·921	3·906	3·890	3·875	3·860	16
51	3·845	3·830	3·815	3·800	3·785	3·770	3·756	3·741	3·727	3·713	15
52	3·698	3·684	3·670	3·656	3·642	3·628	3·614	3·601	3·587	3·574	14
53	3·560	3·547	3·533	3·520	3·507	3·494	3·481	3·468	3·455	3·442	13
54	3·429	3·417	3·404	3·392	3·379	3·367	3·354	3·342	3·330	3·319	12
55	3·3058	·2938	·2819	·2700	·2582	·2464	·2348	·2232	·2117	·2001	117
56	·1888	·1774	·1662	·1549	·1437	·1325	·1215	·1105	·0996	·0887	111
57	·0779	·0671	·0564	·0457	·0351	·0245	·0140	·0036	*·9933	*·9829	106
58	2·9727	·9624	·9523	·9421	·9320	·6220	·9121	·9022	·8923	·8825	100
59	·8727	·8630	·8534	·8437	·8341	·8246	·8152	·8058	·7964	·7871	95
60	·7778	·7685	·7594	·7502	·7411	·7320	·7230	·7141	·7052	·6963	91
61	2·6875	·6787	·6699	·6612	·6525	·6439	·6353	·6268	·6183	·6099	86
62	·6015	·5931	·5848	·5765	·5682	·5600	·5518	·5437	·5356	·5276	82
63	·5195	·5116	·5036	·4957	·4878	·4800	·4722	·4645	·4568	·4491	78
64	2·4414	·4338	·4262	·4187	·4111	·4037	·3962	·3889	·3815	·3742	75
65	·3669	·3596	·3524	·3452	·3380	·3308	·3237	·3167	·3097	·3027	71
66	·2957	·2887	·2818	·2750	·2681	·2613	·2545	·2477	·2410	·2343	67
67	2·2277	·2210	·2144	·2078	·2013	·1948	·1883	·1818	·1754	·1690	65
68	·1626	·1562	·1500	·1437	·1374	·1312	·1249	·1188	·1126	·1065	62
69	·1004	·0943	·0883	·0822	·0762	·0703	·0643	·0584	·0525	·0467	60
70	2·0408	·0350	·0292	·0234	·0177	·0120	·0063	·0006	*·9950	*·9893	57
71	1·9837	·9782	·9726	·9671	·9616	·9561	·9506	·9452	·9398	·9344	55
72	·9290	·9237	·9184	·9130	·9077	·9025	·8972	·8920	·8869	·8817	53
73	1·8765	·8714	·8663	·8612	·8561	·8511	·8460	·8410	·8361	·8311	50
74	·8262	·8212	·8163	·8114	·8066	·8017	·7969	·7921	·7873	·7825	49
75	·7778	·7730	·7683	·7636	·7590	·7543	·7497	·7450	·7405	·7359	47
76	1·7313	·7268	·7224	·7177	·7132	·7087	·7043	·6998	·6954	·6910	45
77	·6866	·6823	·6779	·6736	·6692	·6649	·6606	·6564	·6521	·6479	43
78	·6437	·6395	·6353	·6311	·6269	·6228	·6186	·6145	·6105	·6064	42
79	1·6023	·5983	·5942	·5902	·5862	·5822	·5782	·5743	·5704	·5664	40
80	·5625	·5586	·5547	·5508	·5470	·5431	·5393	·5355	·5317	·5279	38
81	·5242	·5204	·5167	·5129	·5092	·5055	·5018	·4982	·4945	·4908	37
82	1·4872	·4836	·4800	·4764	·4728	·4692	·4657	·4621	·4586	·4551	36
83	·4516	·4481	·4446	·4412	·4377	·4342	·4308	·4274	·4238	·4206	34
84	·4172	·4139	·4105	·4072	·4038	·4005	·3972	·3939	·3906	·3873	33
85	1·3841	·3808	·3776	·3744	·3711	·3679	·3647	·3616	·3584	·3552	32
86	·3521	·3489	·3458	·3427	·3396	·3365	·3334	·3303	·3273	·3242	31
87	·3212	·3181	·3151	·3121	·3091	·3061	·3031	·3002	·2972	·2943	30

X. (*continued*).

$\{1000 \div v\}^2$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
88	1·2913	·2884	·2855	·2826	·2797	·2768	·2739	·2710	·2682	·2653	29
89	·2625	·2596	·2568	·2540	·2512	·2484	·2456	·2428	·2401	·2373	28
90	·2346	·2318	·2291	·2264	·2237	·2210	·2183	·2156	·2129	·2102	27
91	1·2076	·2049	·2023	·1997	·1970	·1944	·1918	·1892	·1866	·1840	26
92	·1815	·1789	·1764	·1738	·1713	·1687	·1662	·1637	·1612	·1587	25
93	·1562	·1537	·1513	·1488	·1463	·1439	·1414	·1390	·1366	·1341	25
94	1·1317	·1293	·1269	·1245	·1222	·1198	·1174	·1151	·1127	·1104	24
95	·1080	·1057	·1034	·1011	·0988	·0965	·0942	·0919	·0896	·0873	23
96	·0851	·0828	·0806	·0783	·0761	·0738	·0716	·0694	·0672	·0650	22
97	1·0628	·0606	·0584	·0563	·0541	·0519	·0498	·0476	·0455	·0434	22
98	·0412	·0391	·0370	·0349	·0328	·0307	·0286	·0265	·0244	·0224	21
99	·0203	·0182	·0161	·0141	·0121	·0101	·0080	·0060	·0040	·0020	20
100	1·0000	*·9980	*·9960	*·9940	*·9920	*·9901	*·9881	*·9861	*·9842	*·9822	20
101	0·9803	·9783	·9764	·9745	·9725	·9707	·9688	·9668	·9649	·9631	19
102	·9612	·9593	·9574	·9555	·9537	·9518	·9500	·9481	·9463	·9444	19
103	0·9426	·9408	·9389	·9371	·9353	·9335	·9317	·9299	·9281	·9263	18
104	·9246	·9228	·9210	·9192	·9175	·9157	·9140	·9124	·9105	·9088	18
105	·9070	·9053	·9036	·9019	·9002	·8985	·8968	·8951	·8934	·8917	17
106	0·8900	·8883	·8866	·8850	·8833	·8817	·8800	·8784	·8767	·8751	17
107	·8734	·8718	·8702	·8686	·8669	·8653	·8637	·8621	·8605	·8589	16
108	·8573	·8558	·8542	·8526	·8510	·8495	·8479	·8463	·8448	·8432	16
109	0·8417	·8401	·8386	·8371	·8355	·8340	·8325	·8310	·8295	·8280	15
110	·8264	·8249	·8234	·8220	·8205	·8190	·8175	·8160	·8146	·8131	15
111	·8116	·8102	·8087	·8073	·8058	·8044	·8029	·8015	·8000	·7986	14
112	0·7972	·7958	·7944	·7929	·7915	·7901	·7887	·7873	·7859	·7845	14
113	·7831	·7818	·7804	·7790	·7776	·7763	·7749	·7735	·7722	·7708	14
114	·7695	·7681	·7668	·7654	·7641	·7628	·7614	·7601	·7588	·7575	13
115	0·7561	·7548	·7535	·7522	·7509	·7496	·7483	·7470	·7457	·7444	13
116	·7432	·7419	·7406	·7393	·7381	·7368	·7355	·7343	·7330	·7318	13
117	·7305	·7293	·7280	·7268	·7255	·7243	·7231	·7219	·7206	·7194	12
118	0·7182	·7170	·7158	·7145	·7133	·7121	·7109	·7097	·7085	·7074	12
119	·7062	·7050	·7038	·7026	·7014	·7003	·6991	·6979	·6968	·6956	12
120	·6944	·6933	·6921	·6910	·6898	·6887	·6876	·6864	·6853	·6841	12
121	0·6830	·6819	·6808	·6796	·6785	·6774	·6763	·6752	·6741	·6730	11
122	·6719	·6708	·6697	·6686	·6675	·6664	·6653	·6642	·6631	·6621	11
123	·6610	·6599	·6588	·6578	·6567	·6556	·6546	·6535	·6525	·6514	11
124	0·6504	·6493	·6483	·6472	·6462	·6452	·6441	·6431	·6421	·6410	10
125	·6400	·6390	·6380	·6369	·6359	·6349	·6339	·6329	·6319	·6309	10
126	·6299	·6289	·6279	·6269	·6259	·6249	·6239	·6229	·6220	·6210	10

X. (*continued*).

$\{1000 \div v\}^2$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
127	0·6200	·6190	·6181	·6171	·6161	·6151	·6142	·6132	·6123	·6113	10
128	·6104	·6094	·6084	·6075	·6066	·6056	·6047	·6037	·6028	·6019	9
129	·6009	·6000	·5991	·5981	·5972	·5963	·5954	·5945	·5935	·5926	9
130	0·5917	·5908	·5899	·5890	·5881	·5872	·5863	·5854	·5845	·5836	9
131	·5827	·5818	·5809	·5801	·5792	·5783	·5774	·5765	·5757	·5748	9
132	·5739	·5731	·5722	·5713	·5705	·5696	·5687	·5679	·5670	·5662	9
133	0·5653	·5645	·5636	·5628	·5619	·5611	·5603	·5594	·5586	·5577	8
134	·5569	·5561	·5553	·5544	·5536	·5528	·5520	·5511	·5503	·5495	8
135	·5487	·5479	·5471	·5463	·5455	·5447	·5439	·5431	·5423	·5415	8
136	0·5 4066	3986	3907	3828	3749	3670	3592	3513	3435	3357	79
137	3279	3202	3124	3047	2970	2893	2816	2739	2663	2586	77
138	2510	2434	2359	2282	2207	2132	2056	1981	1906	1832	75
139	0·5 1757	1683	1608	1534	1461	1387	1313	1240	1166	1093	74
140	1020	0947	0875	0802	0730	0658	0586	0514	0442	0370	72
141	0299	0228	0157	0086	0015	*9944	*9874	*9804	*9733	*9663	71
142	0·4 9593	9524	9454	9384	9314	9246	9177	9108	9039	8971	70
143	8902	8834	8766	8698	8631	8562	8494	8427	8360	8292	68
144	8225	8158	8092	8025	7959	7892	7826	7760	7694	7628	66
145	0·4 7562	7497	7432	7366	7301	7236	7171	7106	7042	6977	65
146	6913	6849	6785	6721	6657	6593	6530	6466	6403	6340	64
147	6277	6215	6152	6089	6026	5964	5901	5839	5777	5716	62
148	0·4 5652	5592	5531	5469	5408	5347	5286	5225	5164	5104	61
149	5043	4983	4922	4862	4802	4742	4682	4623	4563	4504	60
150	4444	4385	4326	4267	4208	4150	4091	4033	3974	3916	59
151	0·4 3858	3800	3742	3684	3626	3569	3511	3454	3397	3340	58
152	3283	3226	3169	3112	3055	2999	2943	2887	2831	2775	56
153	2719	2663	2607	2552	2496	2441	2385	2330	2275	2220	55
154	0·4 2166	2111	2056	2002	1947	1893	1839	1785	1731	1677	54
155	1623	1570	1516	1463	1409	1356	1303	1250	1197	1144	53
156	1091	1039	0986	0934	0881	0829	0777	0725	0673	0621	52
157	0·4 0570	0518	0466	0415	0364	0312	0261	0210	0159	0109	51
158	0058	0007	*9956	*9906	*9856	*9805	*9755	*9705	*9655	*9605	50
159	0·3 9555	9506	9456	9407	9357	9308	9259	9209	9160	9111	49
160	0·3 9063	9014	8965	8916	8868	8820	8771	8723	8675	8627	48
161	8579	8531	8483	8435	8388	8340	8293	8245	8198	8151	48
162	8104	8057	8010	7963	7916	7870	7823	7777	7730	7684	47
163	0·3 7638	7592	7546	7500	7454	7408	7362	7317	7271	7226	46
164	7180	7135	7090	7045	7000	6955	6910	6865	6820	6776	45
165	6731	6686	6642	6598	6554	6509	6465	6421	6377	6334	44

X. (*continued*).

$\{1000 \div v\}^2$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											—
166	0·3 6290	6246	6202	6159	6115	6072	6029	5986	5942	5899	43
167	5856	5813	5771	5728	5685	5643	5600	5558	5515	5473	43
168	5431	5389	5347	5305	5263	5221	5179	5137	5096	5054	42
169	0·3 5013	4971	4930	4889	4848	4807	4766	4725	4684	4643	41
170	4602	4561	4521	4480	4440	4399	4359	4319	4279	4239	40
171	4199	4159	4119	4079	4039	3999	3960	3920	3881	3841	40
172	0·3 3802	3763	3724	3684	3645	3606	3567	3529	3490	3451	39
173	3412	3374	3335	3297	3258	3220	3182	3144	3106	3067	38
174	3029	2992	2954	2916	2878	2840	2803	2765	2728	2690	38
175	0·3 2653	2616	2579	2541	2504	2467	2430	2394	2357	2320	37
176	2283	2246	2210	2173	2137	2100	2064	2028	1991	1955	36
177	1919	1883	1847	1811	1776	1740	1704	1668	1633	1597	36
178	0·3 1562	1526	1491	1456	1421	1385	1350	1315	1280	1245	35
179	1210	1175	1140	1106	1071	1036	1002	0967	0933	0899	34
180	0864	0830	0796	0762	0727	0693	0659	0626	0592	0558	34
181	0·3 0524	0490	0457	0423	0390	0356	0323	0289	0256	0223	33
182	0190	0156	0123	0090	0057	0024	*9992	*9959	*9926	*9893	33
183	0·2 9861	9828	9795	9763	9730	9698	9666	9633	9601	9569	32
184	0·2 9538	9505	9473	9441	9409	9377	9345	9313	9282	9250	32
185	9218	9187	9155	9124	9092	9061	9030	8999	8967	8936	31
186	8905	8874	8843	8812	8781	8750	8719	8689	8658	8627	31
187	0·2 8597	8566	8536	8505	8475	8444	8414	8384	8354	8323	30
188	8293	8263	8233	8203	8173	8143	8114	8084	8054	8024	30
189	7995	7965	7936	7906	7877	7847	7818	7789	7759	7730	29
190	0·2 7700	7672	7643	7614	7585	7556	7527	7498	7469	7440	29
191	7412	7383	7354	7326	7297	7269	7240	7212	7183	7155	29
192	7127	7099	7070	7042	7014	6986	6958	6930	6902	6874	28
193	0·2 6846	6819	6791	6763	6735	6708	6680	6653	6625	6598	28
194	6570	6543	6516	6488	6461	6434	6407	6380	6353	6325	27
195	6298	6272	6245	6218	6191	6164	6137	6111	6084	6057	27
196	0·2 6031	6004	5978	5951	5925	5899	5872	5846	5820	5793	26
197	5767	5741	5715	5689	5663	5637	5611	5585	5559	5533	26
198	5508	5482	5456	5430	5405	5379	5354	5328	5303	5277	26
199	0·2 5252	5227	5201	5176	5151	5125	5100	5075	5050	5025	25
200	5000	4975	4950	4925	4900	4875	4851	4826	4801	4777	25
201	4752	4727	4703	4678	4654	4629	4605	4580	4556	4532	24
202	0·2 4507	4483	4459	4435	4411	4387	4362	4338	4314	4290	24
203	4267	4243	4219	4195	4171	4147	4124	4100	4076	4053	24
204	4029	4006	3982	3959	3935	3912	3888	3865	3842	3819	23

X. (*continued*).

$$\{1000 \div v\}^2.$$

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
205	0·2 3795	3772	3749	3726	3703	3680	3657	3634	3611	3588	23
206	3565	3542	3519	3496	3474	3451	3428	3406	3383	3360	23
207	3338	3315	3293	3270	3248	3225	3203	3181	3158	3136	22
208	0·2 3114	3092	3070	3047	3025	3003	2981	2959	2937	2915	22
209	2893	2871	2849	2827	2806	2784	2762	2741	2719	2697	22
210	2676	2654	2633	2611	2590	2568	2547	2525	2504	2483	21
211	0·2 2461	2440	2419	2398	2376	2355	2334	2313	2292	2271	21
212	2250	2229	2208	2187	2166	2145	2125	2104	2083	2062	21
213	2041	2021	2001	1980	1959	1938	1918	1897	1877	1856	21
214	0·2 1836	1816	1795	1775	1755	1734	1714	1694	1674	1653	20
215	1633	1613	1593	1573	1553	1533	1513	1493	1473	1453	20
216	1433	1414	1394	1374	1354	1335	1315	1295	1276	1256	20
217	0·2 1236	1217	1197	1178	1158	1139	1119	1100	1081	1061	19
218	1042	1023	1003	0984	0965	0946	0927	0908	0888	0869	19
219	0850	0831	0812	0793	0774	0755	0736	0718	0699	0680	19
220	0·2 0661	0642	0624	0605	0586	0568	0549	0530	0512	0493	19
221	0475	0456	0438	0419	0401	0382	0364	0346	0327	0309	18
222	0291	0272	0254	0236	0218	0199	0181	0163	0145	0127	18
223	0·2 0109	0091	0073	0055	0037	0019	0001	*9983	*9965	*9948	18
224	0·1 9930	9912	9894	9877	9859	9841	9824	9806	9788	9771	18
225	9753	9736	9718	9701	9683	9666	9648	9631	9613	9596	17
226	0·1 9579	9561	9544	9527	9510	9492	9475	9458	9441	9424	17
227	9407	9389	9372	9355	9338	9321	9304	9287	9270	9254	17
228	9237	9220	9203	9186	9169	9153	9136	9119	9102	9086	17
229	0·1 9069	9052	9036	9019	9003	8986	8970	8953	8937	8920	17
230	8904	8887	8871	8854	8838	8822	8805	8789	8773	8757	16
231	8740	8724	8708	8692	8676	8659	8643	8627	8611	8595	16
232	0·1 8579	8563	8547	8531	8515	8499	8483	8467	8452	8436	16
233	8420	8404	8388	8373	8357	8341	8325	8310	8294	8278	16
234	8263	8247	8232	8216	8201	8185	8170	8154	8139	8123	16
235	0·1 8108	8092	8077	8062	8046	8031	8016	8000	7985	7970	15
236	7955	7939	7924	7909	7894	7879	7864	7849	7834	7818	15
237	7803	7788	7773	7758	7743	7729	7714	7699	7684	7669	15
238	0·1 7654	7639	7624	7610	7595	7580	7565	7551	7536	7521	15
239	7507	7492	7477	7463	7448	7434	7419	7405	7390	7376	15
240	7361	7347	7332	7318	7303	7289	7275	7260	7246	7232	14
241	0·1 7217	7203	7189	7175	7160	7146	7132	7118	7104	7089	14
242	7075	7061	7047	7033	7019	7005	6991	6977	6963	6949	14
243	6935	6921	6907	6893	6879	6866	6852	6838	6824	6810	14

X. (*continued*).

$\{1000 \div v\}^2$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
244	0·1 6797	6783	6769	6755	6742	6728	6714	6701	6687	6673	14
245	6660	6646	6633	6619	6605	6592	6578	6565	6551	6538	14
246	6525	6511	6498	6484	6471	6458	6444	6431	6418	6404	13
247	0·1 6391	6378	6365	6351	6338	6325	6312	6299	6285	6272	13
248	6259	6246	6233	6220	6207	6194	6181	6168	6155	6142	13
249	6129	6116	6103	6090	6077	6064	6051	6038	6026	6013	13
250	0·1 6000	5987	5974	5962	5949	5936	5923	5911	5898	5885	13
251	5873	5860	5848	5835	5822	5810	5797	5785	5772	5760	13
252	5747	5735	5722	5710	5697	5685	5672	5660	5648	5635	12
253	0·1 5623	5610	5598	5586	5574	5561	5549	5537	5524	5512	12
254	5500	5488	5476	5463	5451	5439	5427	5415	5403	5391	12
255	5379	5367	5355	5343	5331	5319	5307	5295	5283	5271	12
256	0·1 5259	5247	5235	5223	5211	5199	5188	5176	5164	5152	12
257	5140	5129	5117	5105	5093	5082	5070	5058	5047	5035	12
258	5023	5011	5000	4988	4977	4965	4953	4942	4930	4919	12
259	0·1 4907	4896	4884	4873	4861	4850	4839	4827	4816	4804	11
260	4793	4782	4770	4759	4747	4736	4725	4714	4702	4691	11
261	4680	4669	4657	4646	4635	4624	4612	4601	4590	4579	11
262	0·1 4568	4557	4546	4535	4524	4512	4501	4490	4479	4468	11
263	4457	4446	4435	4424	4413	4403	4392	4381	4370	4359	11
264	4348	4337	4326	4315	4305	4294	4283	4272	4261	4251	11
265	0·1 4240	4229	4218	4207	4197	4186	4176	4165	4154	4144	11
266	4133	4122	4112	4101	4091	4080	4070	4059	4048	4038	11
267	4027	4017	4006	3996	3985	3975	3965	3954	3944	3933	10
268	0·1 3923	3913	3902	3892	3881	3871	3861	3850	3840	3830	10
269	3820	3809	3799	3789	3779	3768	3758	3748	3738	3728	10
270	3717	3707	3697	3687	3677	3667	3657	3647	3637	3626	10
271	0·1 3616	3606	3596	3586	3576	3566	3556	3546	3536	3526	10
272	3516	3507	3497	3487	3477	3467	3457	3447	3437	3427	10
273	3418	3408	3398	3388	3378	3369	3359	3349	3339	3330	10
274	0·1 3320	3310	3300	3291	3281	3271	3262	3252	3242	3233	10
275	3223	3214	3204	3194	3185	3175	3166	3156	3147	3137	10
276	3127	3118	3108	3099	3090	3080	3071	3061	3052	3042	9
277	0·1 3033	3023	3014	3005	2995	2986	2977	2967	2958	2949	9
278	2939	2930	2921	2911	2902	2893	2884	2874	2865	2856	9
279	2847	2838	2828	2819	2810	2801	2792	2782	2773	2764	9
280	0·1 2755	2746	2737	2728	2719	2710	2701	2692	2683	2674	9
281	2664	2655	2646	2637	2628	2619	2611	2602	2593	2584	9
282	2575	2566	2557	2548	2539	2530	2521	2513	2504	2495	9
283	0·1 2486	2477	2468	2460	2451	2442	2433	2425	2416	2407	9
284	2398	2390	2381	2372	2363	2355	2346	2337	2329	2320	9

XI.

Coefficients for the Cubic Law of the Resistance of the Air to Spherical Projectiles. ($\omega = 534{\cdot}22$ grains.)

v f. s.	K_v	$\frac{K_v}{g}$	v f. s.	K_v	$\frac{K_v}{g}$	v f. s.	K_v	$\frac{K_v}{g}$
840	140·8	4·374	1390	142·7	4·433	1840	111·9	3·476
to	140·8	4·374	1400	142·1	4·414	1850	111·4	3·461
960	140·8	4·374	1410	141·4	4·393	1860	110·8	3·442
970	140·9	4·377	1420	140·8	4·374	1870	110·3	3·426
980	141·2	4·386	1430	140·1	4·352	1880	109·8	3·411
990	141·5	4·396	1440	139·5	4·334	1890	109·4	3·398
1000	142·0	4·411	1450	138·8	4·312	1900	108·9	3·383
1010	142·8	4·436	1460	138·1	4·290	1910	108·5	3·371
1020	144·0	4·473	1470	137·4	4·268	1920	108·1	3·358
1030	145·5	4·520	1480	136·7	4·247	1930	107·7	3·346
1040	147·5	4·582	1490	136·0	4·225	1940	107·3	3·333
1050	149·2	4·635	1500	135·3	4·203	1950	106·9	3·321
1060	150·5	4·675	1510	134·6	4·181	1960	106·5	3·308
1070	151·6	4·709	1520	133·9	4·160	1970	106·1	3·296
1080	152·6	4·740	1530	133·2	4·138	1980	105·7	3·284
1090	153·4	4·765	1540	132·5	4·116	1990	105·3	3·271
1100	154·1	4·787	1550	131·8	4·094	2000	104·9	3·259
1110	154·6	4·803	1560	131·1	4·073	2010	104·5	3·246
1120	155·1	4·818	1570	130·4	4·051	2020	104·1	3·234
1130	155·4	4·827	1580	129·7	4·029	2030	103·6	3·218
1140	155·7	4·837	1590	129·0	4·007	2040	103·2	3·206
1150	155·9	4·843	1600	128·3	3·986	2050	102·7	3·190
1160	156·0	4·846	1610	127·6	3·964	2060	102·2	3·175
1170	156·0	4·846	1620	126·9	3·942	2070	101·6	3·156
1180	156·0	4·846	1630	126·2	3·920	2080	101·1	3·141
1190	155·8	4·840	1640	125·5	3·899	2090	100·5	3·122
1200	155·5	4·831	1650	124·8	3·877	2100	99·9	3·103
1210	155·1	4·818	1660	124·1	3·855	2110	99·3	3·085
1220	154·6	4·803	1670	123·4	3·833	2120	98·7	3·066
1230	154·0	4·784	1680	122·7	3·812	2130	98·2	3·051
1240	153·4	4·765	1690	122·0	3·790	2140	97·6	3·032
1250	152·7	4·744	1700	121·3	3·768	2150	97·1	3·016
1260	152·0	4·722	1710	120·6	3·746	2160	96·5	2·998
1270	151·3	4·700	1720	119·9	3·725	2170	96·0	2·982
1280	150·5	4·675	1730	119·2	3·703	2180	95·4	2·964
1290	149·6	4·647	1740	118·5	3·681	2190	94·9	2·948
1300	148·7	4·619	1750	117·8	3·659	2200	94·4	2·933
1310	147·9	4·594	1760	117·1	3·638	2210	93·9	2·917
1320	147·2	4·573	1770	116·4	3·616	2220	93·4	2·901
1330	146·6	4·554	1780	115·7	3·594	2230	92·9	2·886
1340	146·0	4·535	1790	115·0	3·572	2240	92·4	2·870
1350	145·3	4·514	1800	114·4	3·554	2250	91·9	2·855
1360	144·7	4·495	1810	113·7	3·532	2260	91·4	2·839
1370	144·0	4·473	1820	113·1	3·513	2270	90·9	2·824
1380	143·4	4·455	1830	112·5	3·495	2280	90·4	2·808

XII.

Coefficients for the Cubic Law of the Resistance of the Air to Ogival-headed Projectiles. ($\omega = 534{\cdot}22$ grains.)

v f. s.	K_v	$\frac{K_v}{g}$	v f. s.	K_v	$\frac{K_v}{g}$	v f. s.	K_v	$\frac{K_v}{g}$
100	605·0	18·79	590	102·5	3·184	1360	107·2	3·330
110	550·0	17·09	600	100·8	3·131	1370	106·8	3·318
120	504·2	15·66	610	99·2	3·082	1380	106·3	3·302
130	465·4	14·46	620	97·6	3·032	1390	105·8	3·287
140	432·1	13·42	630	96·0	2·982	1400	105·2	3·268
150	403·3	12·53	640	94·5	2·936	1410	104·6	3·249
160	378·1	11·75	650	93·1	2·892	1420	104·0	3·231
170	355·9	11·06	660	91·7	2·849	1430	103·4	3·212
180	336·1	10·44	670	90·3	2·805	1440	102·8	3·193
190	318·4	9·891	680	89·0	2·765	1450	102·1	3·172
200	302·5	9·397	690	87·7	2·724	1460	101·4	3·150
210	288·1	8·950	700	86·4	2·684	1470	100·7	3·128
220	275·0	8·543	710	85·2	2·647	1480	99·9	3·103
230	263·0	8·170	720	84·0	2·609	1490	99·2	3·082
240	252·1	7·831	730	82·9	2·575	1500	98·4	3·057
250	242·0	7·518	740	81·8	2·541	1510	97·7	3·035
260	232·7	7·229	750	80·7	2·507	1520	96·8	3·007
270	224·1	6·962	760	79·6	2·473	1530	96·1	2·985
280	216·1	6·713	770	78·6	2·442	1540	95·3	2·960
290	208·6	6·480	780	77·6	2·411	1550	94·5	2·936
300	201·7	6·266	790	76·6	2·380	1560	93·7	2·911
310	195·2	6·064	800	75·6	2·348	1570	92·9	2·886
320	189·1	5·874	810	74·6	2·317	1580	92·1	2·861
330	183·3	5·694	820	73·9	2·296	1590	91·3	2·836
340	177·9	5·526	830	73·6	2·286	1600	90·5	2·811
350	172·9	5·371	840	73·6	2·286	1610	89·8	2·790
360	168·1	5·222	to	73·6	2·286	1620	89·1	2·768
370	163·5	5·079	1000	73·6	2·286	1630	88·4	2·746
380	159·2	4·946	1010	73·8	2·293	1640	87·7	2·724
390	155·1	4·818	1020	74·6	2·317	1650	87·0	2·703
400	151·3	4·700	1030	76·6	2·380	1660	86·3	2·681
410	147·6	4·585	1040	80·8	2·510	1670	85·6	2·659
420	144·0	4·473	1050	87·3	2·712	1680	84·9	2·637
430	140·7	4·371	1060	94·0	2·920	1690	84·2	2·616
440	137·5	4·271	1070	98·7	3·066	1700	83·5	2·594
450	134·4	4·175	1080	102·2	3·175	1710	82·8	2·572
460	131·5	4·084	1090	104·9	3·259	1720	82·1	2·550
470	128·7	3·998	1100	106·9	3·321	1730	81·5	2·532
480	126·0	3·914	1110	108·4	3·367	1740	80·9	2·513
490	123·5	3·836	1120	109·2	3·392	1750	80·3	2·495
500	121·0	3·759	1130	109·6	3·405	1760	79·7	2·476
510	118·6	3·684	to	109·6	3·405	1770	79·2	2·460
520	116·3	3·613	1290	109·6	3·405	1780	78·6	2·442
530	114·2	3·548	1300	109·4	3·398	1790	78·0	2·423
540	112·0	3·479	1310	109·1	3·389	1800	77·4	2·404
550	110·0	3·417	1320	108·8	3·380	1810	76·8	2·386
560	108·0	3·355	1330	108·5	3·371	1820	76·2	2·367
570	106·1	3·296	1340	108·1	3·358	1830	75·7	2·352
580	104·3	3·240	1350	107·7	3·346	1840	75·2	2·336

XII. (*continued*).

v f. s.	K_v	$\frac{K_v}{g}$	v f. s.	K_v	$\frac{K_v}{g}$	v f. s.	K_v	$\frac{K_v}{g}$
1850	74·7	2·321	2170	66·3	2·060	2480	53·6	1·665
1860	74·3	2·308	2180	66·1	2·053	2490	53·2	1·653
1870	73·8	2·293	2190	66·0	2·050	2500	52·9	1·643
1880	73·3	2·277	2200	65·8	2·044	2510	52·7	1·637
1890	72·8	2·262	2210	65·6	2·038	2520	52·5	1·631
1900	72·2	2·243	2220	65·3	2·029	2530	52·3	1·625
1910	71·7	2·227	2230	65·1	2·022	2540	52·2	1·622
1920	71·2	2·212	2240	64·9	2·016	2550	52·0	1·615
1930	70·8	2·199	2250	64·6	2·007	2560	51·9	1·612
1940	70·4	2·187	2260	64·2	1·994	2570	51·8	1·609
1950	70·0	2·175	2270	63·7	1·979	2580	51·7	1·606
1960	69·6	2·162	2280	63·2	1·963	2590	51·6	1·603
1970	69·3	2·153	2290	62·7	1·948	2600	51·5	1·600
1980	69·0	2·143	2300	62·2	1·932	2610	51·4	1·597
1990	68·8	2·137	2310	61·7	1·917	2620	51·4	1·597
2000	68·5	2·128	2320	61·2	1·901	2630	51·4	1·597
2010	68·2	2·119	2330	60·7	1·886	2640	51·4	1·597
2020	68·0	2·112	2340	60·2	1·870	2650	51·4	1·597
2030	67·8	2·106	2350	59·7	1·855	2660	51·4	1·597
2040	67·7	2·103	2360	59·1	1·836	2670	51·4	1·597
2050	67·5	2·097	2370	58·6	1·820	2680	51·4	1·597
2060	67·4	2·094	2380	58·0	1·802	2690	51·3	1·594
2070	67·3	2·091	2390	57·5	1·786	2700	51·3	1·594
2080	67·2	2·088	2400	57·0	1·771	2710	51·3	1·594
2090	67·1	2·084	2410	56·5	1·755	2720	51·3	1·594
2100	67·0	2·081	2420	56·0	1·740	2730	51·2	1·591
2110	66·9	2·078	2430	55·6	1·727	2740	51·2	1·591
2120	66·8	2·075	2440	55·1	1·712	2750	51·2	1·591
2130	66·7	2·072	2450	54·7	1·699	2760	51·2	1·591
2140	66·6	2·069	2460	54·3	1·687	2770	51 2	1·591
2150	66·5	2·066	2470	53·9	1·674	2780	51·2	1·591
2160	66·4	2·063						

XIII.

Coefficients for the Cubic Law of the Resistance of the Air to Hemispherical-headed Projectiles. ($\omega = 534 \cdot 22$ grains.)

v f. s.	K_v	$\frac{K_v}{g}$	κ_1	v f. s.	K_v	$\frac{K_v}{g}$	κ_1	v f. s.	K_v	$\frac{K_v}{g}$	κ_1
1100	133·0	4·13	1·24	1670	115·0	3·57	1·34	1780	109·0	3·39	1·39
1110	133·0	4·13	1·23	1680	114·7	3·56	1·35	1790	108·0	3·36	1·38
1120	133·0	4·13	1·22	1690	114·4	3·55	1·36	1800	107·0	3·32	1·38
1130	133·0	4·13	1·21	1700	114·0	3·54	1·37	1810	106·0	3·29	1·38
1140	133·0	4·13	1·21	1710	113·6	3·53	1·37	1820	104·9	3·26	1·38
1150	133·0	4·13	1·21	1720	113·2	3·52	1·38	1830	103·8	3·22	1·37
1160	133·0	4·13	1·21	1730	112·7	3·50	1·38	1840	102·7	3·19	1·37
......	......	......	......	1740	112·1	3·48	1·39	1850	101·6	3·16	1·36
1640	115·6	3·59	1·32	1750	111·4	3·46	1·39	1860	100·6	3·13	1·35
1650	115·4	3·58	1·33	1760	110·7	3·44	1·39	1870	99·6	3·09	1·35
1660	115·2	3·58	1·33	1770	109·9	3·41	1·39				

XIV.

Coefficients for the Cubic Law of the Resistance of the Air to Flat-headed Projectiles. ($\omega = 534 \cdot 22$ grains.)

v f. s.	K_v	$\frac{K_v}{g}$	κ_2	v f. s.	K_v	$\frac{K_v}{g}$	κ_2	v f. s.	K_v	$\frac{K_v}{g}$	κ_2
1530	174·3	5·41	1·81	1650	173·6	5·39	2·00	1760	171·5	5·33	2·15
1540	174·4	5·42	1·83	1660	173·5	5·39	2·01	1770	171·2	5·32	2·16
1550	174·4	5·42	1·85	1670	173·3	5·38	2·02	1780	170·9	5·31	2·17
1560	174·5	5·42	1·86	1680	173·2	5·38	2·04	1790	170·5	5·29	2·19
1570	174·5	5·42	1·88	1690	173·0	5·37	2·05	1800	170·0	5·28	2·20
1580	174·4	5·42	1·89	1700	172·9	5·37	2·07	1810	169·5	5·27	2·21
1590	174·3	5·41	1·91	1710	172·7	5·36	2·09	1820	168·9	5·25	2·22
1600	174·2	5·41	1·92	1720	172·6	5·36	2·10	1830	168·3	5·23	2·22
1610	174·1	5·41	1·94	1730	172·4	5·36	2·12	1840	167·6	5·21	2·23
1620	174·0	5·41	1·95	1740	172·1	5·35	2·13	1850	166·8	5·18	2·23
1630	173·9	5·40	1·97	1750	171·8	5·34	2·14	1860	165·9	5·15	2·23
1640	173·7	5·40	1·98								

XV.

$P_\phi = 3 \tan \phi + \tan^3 \phi$				$P_\phi = 3 \tan \phi + \tan^3 \phi$			
ϕ	P_ϕ	Log P_ϕ	Log ΔP_ϕ	ϕ	P_ϕ	Log P_ϕ	Log ΔP_ϕ
1°	·05237	8·71909	8·71961	41°	3·26475	0·51385	9·22128
2	·10481	9·02038	8·72067	42	3·43119	0·53545	9·24859
3	·15737	9·19691	8·72226	43	3·60845	0·55732	9·27687
4	·21012	9·32247	8·72439	44	3·79762	0·57951	9·30617
5	·26314	9·42018	8·72704	45	4·00000	0·60206	9·33649
6	·31647	9·50034	8·73023	46	4·21701	0·62501	9·36790
7	·37021	9·56844	8·73394	47	4·45030	0·64839	9·40042
8	·42440	9·62777	8·73821	48	4·70173	0·67226	9·43410
9	·47913	9·68045	8·74302	49	4·97344	0·69666	9·46900
10	·53446	9·72792	8·74836	50	5·26788	0·72164	9·50514
11	·59049	9·77121	8·75426	51	5·58787	0·74725	9·54260
12	·64727	9·81109	8·76070	52	5·93669	0·77355	9·58142
13	·70491	9·84813	8·76770	53	6·31812	0·80059	9·62167
14	·76348	9·88280	8·77527	54	6·73660	0·82844	9·66342
15	·82309	9·91545	8·78338	55	7·19730	0·85717	9·70674
16	·88381	9·94636	8·79208	56	7·70633	0·88685	9·75171
17	·94577	9·97579	8·80136	57	8·27090	0·91755	9·79843
18	1·00906	0·00392	8·81121	58	8·89957	0·94937	9·84697
19	1·07381	0·03093	8·82164	59	9·60260	0·98239	9·89746
20	1·14013	0·05695	8·83269	60	10·3923	1·01671	9·95001
21	1·20816	0·08212	8·84433	61	11·2836	1·05245	0·00475
22	1·27803	0·10654	8·85658	62	12·2946	1·08971	0·06179
23	1·34991	0·13030	8·86945	63	13·4475	1·12864	0·12136
24	1·42394	0·15349	8·88295	64	14·7699	1·16938	0·18358
25	1·50032	0·17618	8·89709	65	16·2959	1·21208	0·24864
26	1·57922	0·19844	8·91188	66	18·0687	1·25693	0·31681
27	1·66086	0·22033	8·92733	67	20·1426	1·30412	0·38830
28	1·74545	0·24191	8·94346	68	22·5878	1·35387	0·46343
29	1·83324	0·26322	8·96027	69	25·4947	1·40645	0·54249
30	1·92450	0·28432	8·97778	70	28·9820	1·46213	0·62593
31	2·01951	0·30525	8·99600	71	33·2080	1·52124	0·71410
32	2·11860	0·32605	9·01495	72	38·3853	1·58417	0·80756
33	2·22210	0·34676	9·03464	73	44·8057	1·65133	0·90691
34	2·33040	0·36743	9·05510	74	52·8763	1·72326	1·01288
35	2·44393	0·38809	9·07633	75	63·1771	1·80056	1·12626
36	2·56314	0·40877	9·09837	76	76·5513	1·88395	1·24819
37	2·68856	0·42952	9·12122	77	94·2603	1·97433	1·37992
38	2·82076	0·45037	9·14491	78	118·244	2·07278	1·52307
39	2·96037	0·47135	9·16947	79	151·592	2·18068	1·67970
40	3·10810	0·49250	9·19492	80	199·422	2·29977	

XVI.

Table for $\gamma = 0{\cdot}00$ is the same as that for $\lambda = 0{\cdot}00$ (p. 8).

$\gamma = 0{\cdot}01$					$\gamma = 0{\cdot}03$				
ϕ	(X)	(Y)	(T)	(V)	ϕ	(X)	(Y)	(T)	(V)
45°	10119	5082	10059	1434	45°	10374	5259	10184	1476
44	9767	4736	9712	1408	44	10001	4892	9827	1448
43	9428	4413	9376	1384	43	9642	4551	9482	1421
42	9098	4111	9051	1362	42	9296	4234	9148	1395
41	8780	3830	8736	1340	41	8962	3939	8826	1371
40	8471	3566	8431	1320	40	8639	3663	8514	1348
39	8172	3320	8135	1300	39	8327	3406	8211	1327
38	7881	3088	7847	1282	38	8024	3165	7918	1307
37	7599	2872	7567	1264	37	7731	2940	7632	1288
36	7324	2668	7294	1247	36	7445	2728	7355	1270
35	7056	2477	7029	1231	35	7168	2530	7084	1252
34	6795	2297	6770	1216	34	6898	2345	6821	1236
33	6540	2129	6517	1201	33	6635	2171	6564	1220
32	6291	1970	6270	1188	32	6378	2007	6313	1205
31	6047	1821	6028	1175	31	6127	1854	6068	1191

$\gamma = 0{\cdot}02$					$\gamma = 0{\cdot}04$				
ϕ	(X)	(Y)	(T)	(V)	ϕ	(X)	(Y)	(T)	(V)
45°	10244	5168	10121	1454	45°	10510	5354	10250	1499
44	9881	4812	9768	1427	44	10126	4976	9887	1469
43	9532	4481	9428	1402	43	9756	4626	9537	1440
42	9195	4172	9099	1378	42	9401	4300	9200	1413
41	8869	3883	8780	1355	41	9059	3997	8873	1388
40	8554	3614	8472	1333	40	8728	3715	8557	1364
39	8248	3362	8173	1313	39	8409	3451	8251	1342
38	7952	3126	7882	1294	38	8099	3205	7954	1321
37	7664	2905	7599	1275	37	7800	2975	7666	1301
36	7384	2698	7324	1258	36	7509	2760	7386	1281
35	7111	2503	7056	1241	35	7226	2558	7113	1263
34	6846	2321	6795	1226	34	6951	2370	6847	1246
33	6587	2149	6540	1211	33	6684	2192	6588	1230
32	6334	1988	6291	1197	32	6423	2026	6335	1215
31	6087	1837	6048	1183	31	6169	1870	6088	1200

XVI. (*continued*).

$\gamma=0{\cdot}05$					$\gamma=0{\cdot}05$				
ϕ	(X)	(Y)	(T)	(V)	ϕ	(X)	(Y)	(T)	(V)
45°	10653	5454	10319	1523	1°	175	1·5	175	999
44	10256	5065	9950	1491	2	349	6·1	349	999
43	9876	4704	9595	1461	3	523	13·7	523	999
42	9511	4369	9252	1433	4	697	24·3	698	999
41	9159	4058	8922	1406	5	871	38·1	873	1000
40	8820	3768	8602	1381	6	1046	54·9	1048	1000
39	8493	3499	8292	1357	7	1220	74·8	1224	1001
38	8177	3247	7992	1335	8	1396	97·8	1401	1003
37	7871	3012	7701	1314	9	1571	124·1	1578	1005
36	7574	2793	7418	1294	10	1748	153·7	1756	1007
35	7286	2587	7142	1275	11	1925	186·5	1935	1009
34	7006	2395	6874	1257	12	2103	222·7	2114	1012
33	6734	2215	6613	1240	13	2282	262·5	2296	1015
32	6469	2046	6358	1224	14	2463	305·7	2478	1018
31	6211	1888	6109	1209	15	2644	352·6	2662	1021
30	5959	1739	5865	1194	16	2827	403·3	2847	1025
29	5713	1600	5627	1181	17	3011	457·9	3034	1030
28	5473	1470	5394	1168	18	3197	516·5	3223	1034
27	5237	1347	5166	1156	19	3385	579·3	3414	1039
26	5007	1232	4941	1144	20	3574	646·4	3607	1045
25	4781	1124	4721	1133	21	3766	718·0	3802	1050
24	4559	1023	4505	1122	22	3959	794·3	4000	1057
23	4341	928·5	4293	1112	23	4155	875·5	4200	1063
22	4127	839·8	4083	1103	24	4354	961·8	4403	1070
21	3917	756·9	3877	1094	25	4555	1053	4609	1077
20	3710	679·5	3674	1086	26	4759	1151	4818	1085
19	3506	607·2	3474	1078	27	4966	1254	5030	1093
18	3305	539·9	3277	1070	28	5176	1363	5246	1101
17	3106	477·4	3082	1063	29	5389	1479	5465	1110
16	2910	419·3	2889	1056	30	5606	1602	5689	1120
15	2717	365·7	2698	1050	31	5827	1732	5917	1130
14	2525	316·2	2509	1044	32	6052	1870	6149	1140
13	2336	270·8	2322	1039	33	6281	2016	6386	1151
12	2149	229·2	2137	1034	34	6515	2170	6628	1163
11	1963	191·4	1954	1029	35	6753	2334	6876	1175
10	1779	157·3	1771	1025	36	6996	2508	7129	1187
9	1597	126·8	1590	1021	37	7245	2692	7388	1201
8	1415	99·7	1410	1017	38	7500	2887	7654	1214
7	1236	76·0	1232	1014	39	7760	3095	7926	1229
6	1057	55·6	1054	1011	40	8027	3315	8206	1244
5	879	38·5	877	1008	41	8300	3548	8494	1260
4	702	24·6	701	1006	42	8581	3797	8789	1277
3	526	13·8	525	1004	43	8869	4061	9093	1294
2	350	6·1	350	1002	44	9166	4342	9407	1312
1	175	1·5	175	1001	45	9470	4641	9730	1331
0	0	0	0	1000					

XVI. (*continued*).

$\gamma = 0\cdot05$

ϕ	(X)	(Y)	(T)	(V)
46°	9784	4961	10064	1351
47	10107	5301	10409	1371
48	10441	5665	10766	1393
49	10785	6054	11136	1416
50	11140	6470	11519	1439
51	11508	6916	11918	1464
52	11888	7395	12332	1489
53	12282	7909	12763	1516
54	12691	8461	13212	1544
55	13115	9056	13680	1574
56	13556	9697	14170	1604
57	14014	10389	14682	1636
58	14491	11138	15219	1669
59	14987	11948	15782	1704
60	15504	12826	16374	1740

$\gamma = 0\cdot07$

ϕ	(X)	(Y)	(T)	(V)
45°	10962	5674	10465	1577
44	10537	5257	10083	1541
43	10132	4873	9717	1507
42	9744	4517	9364	1475
41	9372	4188	9024	1445
40	9015	3883	8695	1417
39	8672	3600	8378	1390
38	8340	3336	8071	1365
37	8020	3091	7773	1342
36	7711	2862	7484	1320
35	7412	2648	7203	1300
34	7122	2449	6930	1281
33	6840	2262	6664	1262
32	6566	2087	6404	1244
31	6299	1924	6152	1227

$\gamma = 0\cdot06$

ϕ	(X)	(Y)	(T)	(V)
45°	10803	5561	10390	1550
44	10393	5158	10015	1515
43	10001	4786	9655	1483
42	9625	4441	9307	1453
41	9264	4122	8972	1425
40	8916	3825	8648	1399
39	8581	3548	8334	1374
38	8257	3291	8031	1350
37	7944	3051	7736	1328
36	7642	2827	7450	1307
35	7348	2617	7172	1287
34	7063	2421	6902	1269
33	6786	2238	6638	1251
32	6517	2067	6381	1234
31	6255	1906	6130	1218

$\gamma = 0\cdot08$

ϕ	(X)	(Y)	(T)	(V)
45°	11129	5795	10543	1608
44	10689	5362	10154	1569
43	10270	4964	9781	1532
42	9869	4597	9422	1498
41	9486	4258	9077	1466
40	9119	3944	8744	1436
39	8766	3653	8423	1408
38	8426	3383	8111	1382
37	8099	3132	7810	1357
36	7783	2898	7518	1334
35	7477	2680	7234	1313
34	7181	2477	6958	1292
33	6894	2287	6690	1273
32	6616	2109	6429	1255
31	6345	1943	6174	1237

XVI. (*continued*).

$\gamma = 0{\cdot}09$

ϕ	(X)	(Y)	(T)	(V)
45°	11307	5923	10624	1641
44	10849	5473	10228	1599
43	10414	5061	9848	1559
42	10000	4681	9483	1522
41	9605	4332	9133	1488
40	9227	4009	8795	1457
39	8864	3710	8469	1427
38	8516	3432	8154	1399
37	8181	3175	7849	1373
36	7857	2936	7553	1349
35	7545	2713	7266	1326
34	7243	2506	6988	1304
33	6951	2312	6717	1284
32	6667	2131	6453	1265
31	6391	1962	6196	1247

$\gamma = 0{\cdot}10$

ϕ	(X)	(Y)	(T)	(V)
45°	11495	6061	10709	1677
44	11018	5592	10305	1630
43	10567	5163	9918	1587
42	10138	4770	9547	1548
41	9730	4409	9190	1512
40	9340	4076	8847	1478
39	8967	3769	8516	1447
38	8609	3484	8197	1417
37	8265	3220	7888	1390
36	7934	2975	7589	1364
35	7615	2747	7300	1340
34	7307	2536	7018	1318
33	7009	2338	6745	1297
32	6720	2154	6478	1277
31	6439	1982	6219	1258
30	6167	1822	5966	1240
29	5903	1672	5719	1223
28	5645	1532	5478	1207
27	5394	1402	5242	1192
26	5148	1279	5010	1178

$\gamma = 0{\cdot}10$

ϕ	(X)	(Y)	(T)	(V)
25°	4909	1165	4784	1165
24	4675	1058	4562	1152
23	4445	958·6	4344	1140
22	4221	865·5	4129	1129
21	4001	778·8	3918	1118
20	3784	697·9	3711	1108
19	3572	622·7	3507	1098
18	3363	552·8	3305	1089
17	3158	488·0	3107	1081
16	2955	428·0	2911	1073
15	2756	372·7	2717	1065
14	2559	321·8	2526	1058
13	2365	275·2	2336	1052
12	2173	232·6	2149	1045
11	1983	194·0	1963	1040
10	1796	159·3	1779	1034
9	1610	128·2	1597	1029
8	1426	100·7	1416	1025
7	1243	76·7	1236	1020
6	1062	56·0	1057	1016
5	883	38·7	879	1013
4	704	24·7	702	1010
3	527	13·8	526	1007
2	350	6·1	350	1004
1	175	1·5	175	1002
0	0	0	0	1000
1	174	1·5	174	998
2	348	6·1	349	997
3	521	13·6	523	996
4	694	24·2	697	996
5	867	37·8	871	995
6	1040	54·5	1046	995
7	1213	74·2	1220	995
8	1386	97·0	1396	996
9	1559	122·8	1572	997
10	1733	151·9	1748	998
11	1907	184·2	1925	999
12	2082	219·7	2104	1001
13	2257	258·6	2283	1003
14	3433	300·8	2463	1006
15	2610	346·6	2644	1008

XVI. (*continued*).

$\gamma = 0{\cdot}10$				
ϕ	(X)	(Y)	(T)	(V)
16°	2788	396·0	2827	1011
17	2967	449·0	3012	1015
18	3147	505·9	3198	1018
19	3329	566·7	3386	1022
20	3512	631·5	3575	1027
21	3697	700·6	3767	1031
22	3883	774·1	3961	1036
23	4072	852·1	4157	1041
24	4262	934·8	4356	1047
25	4455	1023	4557	1053
26	4649	1115	4761	1060
27	4846	1214	4969	1066
28	5046	1318	5179	1073
29	5249	1428	5393	1081
30	5454	1544	5611	1089
31	5663	1667	5832	1097
32	5874	1797	6058	1106
33	6090	1934	6288	1115
34	6309	2079	6522	1125
35	6531	2232	6761	1135
36	6758	2394	7006	1146
37	6990	2565	7256	1157
38	7225	2746	7511	1168
39	7466	2937	7773	1180
40	7712	3140	8042	1193
41	7963	3354	8317	1206
42	8219	3581	8599	1220
43	8482	3822	8890	1234
44	8751	4077	9189	1249
45	9027	4348	9496	1264
46	9309	4635	9813	1280
47	9599	4941	10140	1297
48	9896	5266	10477	1314
49	10202	5611	10825	1332
50	10516	5979	11186	1351
51	10839	6371	11559	1370
52	11172	6789	11946	1391
53	11514	7236	12348	1411
54	11867	7713	12765	1433
55	12231	8223	13199	1455

$\gamma = 0{\cdot}10$				
ϕ	(X)	(Y)	(T)	(V)
56°	12607	8769	13651	1478
57	12994	9355	14123	1502
58	13394	9983	14615	1526
59	13808	10658	15129	1551
60	14235	11383	15667	1577

$\gamma = 0{\cdot}12$				
ϕ	(X)	(Y)	(T)	(V)
45°	11912	6369	10894	1759
44	11390	5856	10471	1703
43	10899	5390	10067	1652
42	10436	4966	9682	1606
41	9998	4578	9312	1564
40	9581	4222	8958	1525
39	9185	3895	8617	1490
38	8806	3594	8289	1456
37	8444	3316	7972	1426
36	8096	3059	7665	1397
35	7762	2820	7368	1371
34	7440	2599	7081	1346
33	7130	2394	6802	1322
32	6830	2202	6530	1300
31	6539	2024	6266	1280
30	6258	1859	6009	1260
29	5985	1704	5758	1242
28	5719	1560	5513	1225
27	5461	1425	5274	1208
26	5209	1300	5040	1193
25	4964	1183	4810	1179
24	4724	1073	4585	1165
23	4490	971·5	4365	1152
22	4260	876·5	4148	1140
21	4036	788·0	3936	1129
20	3816	705·7	3726	1118

XVI. (*continued*).

$\gamma = 0 \cdot 14$

ϕ	(X)	(Y)	(T)	(V)
45°	12396	6734	11102	1859
44	11815	6163	10655	1790
43	11275	5650	10232	1728
42	10770	5187	9829	1674
41	10296	4768	9445	1624
40	9848	4385	9078	1579
39	9425	4036	8725	1538
38	9022	3716	8386	1500
37	8638	3421	8060	1466
36	8271	3150	7745	1433
35	7920	2899	7441	1404
34	7583	2667	7147	1376
33	7259	2453	6862	1350
32	6947	2254	6585	1326
31	6645	2069	6316	1303
30	6354	1897	6054	1282
29	6071	1737	5799	1262
28	5797	1589	5550	1244
27	5531	1450	5307	1226
26	5273	1321	5070	1209
25	5021	1201	4837	1194
24	4775	1089	4610	1179
23	4535	984·8	4387	1165
22	4301	887·8	4168	1151
21	4072	797·6	3953	1139
20	3848	713·7	3742	1128

$\gamma = 0 \cdot 16$

ϕ	(X)	(Y)	(T)	(V)
45°	12970	7175	11339	1988
44	12312	6528	10863	1899
43	11708	5955	10416	1822
42	11150	5444	9993	1755
41	10631	4985	9591	1695
40	10146	4570	9208	1642
39	9689	4193	8842	1594
38	9258	3850	8491	1550
37	8850	3537	8155	1510
36	8461	3249	7831	1474

$\gamma = 0 \cdot 16$

ϕ	(X)	(Y)	(T)	(V)
35°	8091	2985	7519	1440
34	7737	2742	7217	1409
33	7397	2517	6925	1380
32	7071	2309	6642	1354
31	6757	2117	6368	1329
30	6454	1938	6101	1305
29	6162	1773	5841	1284
28	5879	1619	5588	1263
27	5605	1476	5342	1244
26	5339	1344	5101	1226
25	5080	1220	4865	1209
24	4828	1105	4635	1193
23	4583	998·7	4409	1178
22	4343	899·6	4188	1164
21	4110	807·5	3971	1151
20	3881	722·0	3758	1138

$\gamma = 0 \cdot 18$

ϕ	(X)	(Y)	(T)	(V)
45°	13677	7732	11616	2162
44	12907	6976	11102	2040
43	12217	6320	10624	1939
42	11590	5746	10175	1854
41	11014	5236	9752	1780
40	10481	4781	9351	1716
39	9985	4371	8969	1658
38	9520	4001	8605	1607
37	9082	3665	8257	1561
36	8668	3359	7922	1519
35	8276	3079	7601	1481
34	7902	2822	7291	1446
33	7545	2586	6992	1414
32	7204	2368	6702	1384
31	6876	2168	6422	1356
30	6561	1982	6150	1331
29	6258	1810	5885	1307
28	5965	1651	5628	1284
27	5682	1504	5378	1263
26	5408	1367	5133	1244

XVI. (*continued*).

$\gamma = 0{\cdot}18$

ϕ	(X)	(Y)	(T)	(V)
25°	5142	1240	4894	1225
24	4883	1123	4661	1208
23	4632	1013	4433	1192
22	4387	911·8	4209	1177
21	4149	817·8	3989	1163
20	3915	730·6	3774	1149

$\gamma = 0{\cdot}20$

ϕ	(X)	(Y)	(T)	(V)
45°	14592	8474	11954	2418
44	13650	7548	11385	2235
43	12834	6773	10865	2094
42	12110	6110	10383	1980
41	11459	5533	9933	1886
40	10865	5026	9510	1805
39	10319	4576	9109	1735
38	9812	4173	8729	1674
37	9339	3810	8367	1619
36	8896	3481	8021	1571
35	8477	3183	7689	1527
34	8081	2910	7370	1487
33	7705	2661	7063	1450
32	7346	2433	6766	1417
31	7003	2223	6479	1386
30	6675	2029	6201	1358
29	6359	1850	5932	1331
28	6056	1686	5670	1307
27	5763	1533	5415	1284
26	5480	1392	5167	1263
25	5206	1261	4924	1243
24	4941	1140	4688	1224
23	4683	1028	4456	1207
22	4432	924·5	4230	1190
21	4188	828·4	4008	1175
20	3951	739·5	3791	1160
19	3719	657·3	3577	1146
18	3492	581·4	3368	1134
17	3270	511·4	3161	1121
16	3053	447·1	2958	1110

$\gamma = 0{\cdot}20$

ϕ	(X)	(Y)	(T)	(V)
15°	2840	388·0	2758	1099
14	2631	334·0	2561	1089
13	2426	284·7	2366	1080
12	2224	240·0	2174	1071
11	2025	199·6	1984	1062
10	1830	163·3	1796	1054
9	1637	131·1	1610	1047
8	1447	102·7	1426	1040
7	1259	78·0	1244	1034
6	1074	56·9	1063	1028
5	891	39·2	883	1022
4	709	24·9	704	1017
3	530	13·9	527	1012
2	352	6·2	351	1008
1	175	1·5	175	1004
0	0	0	0	1000
1	174	1·5	174	997
2	347	6·0	348	994
3	519	13·6	521	991
4	690	24·0	695	989
5	860	37·4	867	987
6	1030	53·7	1040	985
7	1199	73·0	1213	984
8	1368	95·2	1386	983
9	1536	120·4	1560	982
10	1704	148·6	1733	982
11	1872	179·7	1908	982
12	2041	213·9	2083	982
13	2209	251·2	2258	982
14	2377	291·7	2434	983
15	2546	335·4	2612	984
16	2715	382·3	2790	985
17	2885	432·6	2970	987
18	3055	486·3	3150	989
19	3226	543·4	3333	991
20	3398	604·4	3516	994
21	3571	669·0	3702	997
22	3745	737·5	3889	1000
23	3920	810·0	4078	1003
24	4096	886·7	4269	1007
25	4274	967·7	4463	1011
26	4453	1053	4659	1015
27	4634	1143	4857	1020
28	4816	1238	5059	1025
29	5001	1338	5263	1030
30	5187	1444	5470	1036

XVI. (*continued*).

$\gamma = 0{\cdot}20$

ϕ	(x)	(y)	(T)	(v)
31°	5375	1555	5680	1042
32	5566	1671	5894	1048
33	5759	1794	6112	1055
34	5954	1924	6333	1062
35	6152	2060	6559	1069
36	6353	2203	6789	1077
37	6557	2354	7024	1085
38	6764	2513	7263	1093
39	6975	2680	7508	1102
40	7188	2856	7758	1111
41	7406	3042	8014	1121
42	7627	3238	8277	1131
43	7852	3444	8546	1141
44	8081	3662	8821	1152
45	8315	3891	9104	1163
46	8553	4134	9395	1174
47	8796	4390	9695	1186
48	9044	4660	10003	1198
49	9297	4947	10320	1211
50	9556	5250	10647	1224
51	9820	5570	10985	1237
52	10090	5910	11334	1251
53	10367	6270	11694	1266
54	10649	6652	12068	1280
55	10939	7058	12455	1295
56	11235	7489	12856	1310
57	11538	7948	13273	1326
58	11849	8435	13707	1342
59	12167	8955	14158	1358
60	12493	9508	14628	1375

$\gamma = 0{\cdot}22$

ϕ	(x)	(y)	(T)	(v)
45°	15901	9575	12394	2867
44	14637	8332	11736	2537
43	13614	7361	11153	2315
42	12747	6566	10626	2150
41	11989	5895	10140	2021

$\gamma = 0{\cdot}22$

ϕ	(x)	(y)	(T)	(v)
40°	11314	5318	9689	1916
39	10703	4814	9265	1828
38	10144	4369	8866	1753
37	9628	3973	8488	1688
36	9148	3618	8128	1630
35	8699	3298	7784	1579
34	8277	3007	7455	1533
33	7878	2743	7138	1491
32	7499	2502	6834	1454
31	7139	2282	6540	1419
30	6796	2079	6255	1387
29	6467	1893	5980	1358
28	6152	1722	5713	1331
27	5848	1564	5454	1306
26	5556	1418	5201	1283
25	5274	1284	4955	1261
24	5001	1159	4716	1241
23	4736	1044	4481	1222
22	4479	937·7	4252	1204
21	4230	839·4	4028	1187
20	3987	748·7	3808	1172

$\gamma = 0{\cdot}24$

ϕ	(x)	(y)	(T)	(v)
44°	16126	9568	12208	3119
43	14682	8192	11517	2672
42	13566	7170	10919	2399
41	12644	6353	10383	2207
40	11851	5676	9894	2061
39	11152	5100	9441	1945
38	10525	4600	9018	1850
37	9954	4162	8621	1769
36	9430	3774	8244	1699
35	8944	3427	7887	1639
34	8491	3116	7545	1585
33	8066	2834	7219	1537
32	7665	2579	6905	1494
31	7285	2346	6603	1455

XVI. (*continued*).

$\gamma = 0{\cdot}24$

ϕ	(X)	(Y)	(T)	(V)
30°	6925	2134	6312	1420
29	6581	1939	6031	1387
28	6253	1761	5758	1357
27	5938	1597	5494	1330
26	5635	1446	5237	1304
25	5344	1307	4987	1280
24	5062	1180	4744	1258
23	4791	1061	4506	1238
22	4527	951·7	4274	1219
21	4272	851·1	4047	1201
20	4024	758·3	3825	1184

$\gamma = 0{\cdot}26$

ϕ	(X)	(Y)	(T)	(V)
42°	14725	8052	11297	2827
41	13504	6971	10681	2487
40	12524	6133	10137	2263
39	11696	5451	9645	2099
38	10974	4876	9191	1972
37	10331	4383	8769	1868
36	9751	3953	8373	1782
35	9219	3574	7999	1709
34	8729	3237	7644	1645
33	8272	2935	7305	1589
32	7845	2663	6982	1540
31	7444	2416	6671	1495
30	7064	2193	6372	1455
29	6704	1989	6084	1419
28	6361	1803	5806	1386
27	6033	1632	5536	1355
26	5719	1475	5275	1327
25	5418	1332	5021	1301
24	5128	1200	4773	1277
23	4848	1078	4532	1255
22	4578	966·0	4297	1234
21	4317	863·0	4068	1215
20	4063	768·2	3843	1196

$\gamma = 0{\cdot}28$

ϕ	(X)	(Y)	(T)	(V)
41°	14763	7911	11075	3003
40	13421	6763	10439	2579
39	12381	5905	9887	2318
38	11519	5219	9391	2134
37	10776	4649	8938	1995
36	10121	4164	8517	1884
35	9532	3743	8123	1793
34	8995	3375	7752	1716
33	8501	3048	7400	1649
32	8044	2756	7065	1591
31	7616	2494	6744	1541
30	7214	2257	6437	1495
29	6835	2043	6141	1453
28	6476	1847	5856	1416
27	6134	1669	5581	1383
26	5808	1507	5314	1352
25	5496	1358	5056	1323
24	5197	1221	4804	1297
23	4909	1096	4560	1273
22	4631	981·2	4322	1250
21	4363	875·6	4089	1229
20	4103	778·5	3862	1210

$\gamma = 0{\cdot}30$

ϕ	(X)	(Y)	(T)	(V)
40°	14791	7761	10848	3205
39	13312	6541	10190	2670
38	12213	5666	9631	2369
37	11320	4980	9133	2164
36	10560	4418	8680	2014
35	9894	3942	8262	1896
34	9298	3533	7870	1800
33	8758	3176	7502	1720
32	8263	2860	7154	1651
31	7805	2579	6822	1591

XVI. (*continued*).

$\gamma=0·30$					$\gamma=0·30$				
ϕ	(X)	(Y)	(T)	(V)	ϕ	(X)	(Y)	(T)	(V)
30°	7378	2327	6505	1539	16°	2649	369·8	2755	962
29	6977	2101	6201	1492	17	2810	417·7	2930	962
28	6600	1896	5909	1450	18	2972	468·7	3106	963
27	6242	1710	5628	1412	19	3134	522·8	3284	964
26	5903	1540	5356	1378	20	3296	580·3	3462	965
25	5579	1386	5092	1347	21	3459	641·1	3642	966
24	5269	1244	4837	1318	22	3622	705·4	3824	968
23	4972	1115	4588	1292	23	3786	773·3	4007	970
22	4686	997·0	4347	1267	24	3950	844·9	4191	972
21	4411	888·5	4111	1245	25	4116	920·3	4378	975
20	4145	789·2	3881	1224	26	4282	999·6	4567	978
19	3888	698·1	3656	1204	27	4449	1083	4758	981
18	3639	614·7	3437	1186	28	4618	1171	4951	984
17	3397	538·5	3221	1169	29	4788	1263	5147	988
16	3162	468·8	3010	1153	30	4959	1360	5346	992
15	2933	405·3	2802	1138	31	5131	1461	5547	996
14	2710	347·6	2599	1124	32	5305	1568	5751	1001
13	2492	295·2	2398	1111	33	5481	1680	5959	1006
12	2279	248·0	2201	1099	34	5658	1797	6170	1011
11	2071	205·6	2006	1087	35	5837	1921	6385	1016
10	1866	167·7	1814	1076	36	6019	2050	6603	1022
9	1666	134·2	1624	1066	37	6202	2186	6826	1028
8	1469	104·8	1437	1057	38	6388	2328	7053	1035
7	1276	79·4	1252	1048	39	6576	2477	7284	1041
6	1086	57·7	1068	1040	40	6766	2634	7520	1048
5	899	39·7	887	1032	41	6959	2799	7762	1055
4	715	25·2	707	1024	42	7155	2973	8009	1063
3	533	14·0	528	1018	43	7353	3155	8261	1071
2	353	6·2	351	1011	44	7555	3346	8520	1079
1	176	1·5	175	1005	45	7760	3547	8785	1087
0	0	0	0	1000					
1	174	1·5	174	995	46	7968	3759	9057	1096
2	346	6·0	347	990	47	8179	3982	9336	1105
3	516	13·5	520	986	48	8394	4216	9622	1115
4	685	23·8	692	982	49	8613	4464	9917	1124
5	853	37·0	864	979	50	8836	4724	10221	1134
6	1020	53·0	1035	976	51	9062	4999	10533	1144
7	1185	71·9	1206	973	52	9293	5289	10856	1155
8	1350	93·6	1377	970	53	9528	5595	11189	1166
9	1514	118·1	1548	968	54	9767	5919	11532	1177
10	1677	145·4	1719	966	55	10011	6261	11888	1188
11	1840	175·6	1891	965	56	10260	6623	12256	1200
12	2002	208·6	2063	964	57	10514	7006	12637	1211
13	2164	244·5	2235	963	58	10772	7413	13032	1223
14	2326	283·3	2408	962	59	11036	7843	13443	1236
15	2487	325·1	2581	962	60	11305	8300	13870	1248

XVI. (*continued*).

$\gamma = 0{\cdot}35$

ϕ	(X)	(Y)	(T)	(V)
37°	13690	6512	9864	3216
36	12225	5427	9236	2638
35	11159	4666	8707	2326
34	10301	4076	8237	2119
33	9574	3595	7810	1968
32	8939	3190	7415	1851
31	8372	2842	7046	1756
30	7858	2539	6699	1677
29	7387	2273	6369	1610
28	6952	2036	6056	1551
27	6546	1825	5756	1500
26	6165	1635	5467	1455
25	5806	1463	5190	1414
24	5466	1308	4922	1378
23	5143	1168	4663	1345
22	4834	1040	4412	1314
21	4539	923·8	4168	1287
20	4256	817·9	3931	1261

$\gamma = 0{\cdot}40$

ϕ	(X)	(Y)	(T)	(V)
34°	12157	5144	8813	2958
33	10889	4304	8250	2480
32	9938	3697	7767	2207
31	9161	3221	7335	2022
30	8498	2830	6940	1884
29	7914	2500	6574	1776
28	7391	2215	6230	1689
27	6916	1968	5905	1615
26	6478	1750	5596	1552
25	6073	1556	5302	1498
24	5694	1383	5019	1450
23	5338	1229	4747	1407
22	5002	1089	4485	1369
21	4683	963·7	4231	1335

$\gamma = 0{\cdot}40$

ϕ	(X)	(Y)	(T)	(V)
20°	4379	850·1	3986	1304
19	4089	747·4	3747	1275
18	3811	654·3	3515	1249
17	3544	570·1	3288	1225
16	3287	493·9	3067	1203
15	3038	425·0	2851	1183
14	2798	362·9	2640	1164
13	2565	307·0	2432	1146
12	2339	256·9	2229	1130
11	2120	212·2	2029	1114
10	1906	172·5	1833	1100
9	1697	137·6	1639	1087
8	1493	107·1	1448	1074
7	1294	80·9	1260	1063
6	1099	58·6	1075	1052
5	908	40·2	891	1042
4	720	25·4	709	1032
3	536	14·1	530	1023
2	354	6·2	352	1015
1	176	1·5	175	1007
0	0	0	0	1000
1	173	1·5	174	993
2	344	6·0	347	987
3	514	13·4	519	981
4	681	23·6	690	976
5	846	36·6	860	971
6	1010	52·4	1030	966
7	1172	70·9	1200	962
8	1333	92·0	1369	958
9	1493	115·9	1537	955
10	1651	142·5	1706	952
11	1809	171·7	1875	949
12	1966	203·6	2044	947
13	2122	238·2	2213	945
14	2277	275·5	2382	943
15	2432	315·6	2552	942
16	2587	358·5	2722	940
17	2741	404·2	2894	940
18	2895	452·7	3065	939
19	3049	504·2	3238	939
20	3203	558·7	3412	939

XVI. (*continued*).

$\gamma = 0·40$

ϕ	(X)	(Y)	(T)	(V)
21°	3357	616·2	3587	939
22	3511	676·9	3763	940
23	3665	740·8	3941	941
24	3820	808·1	4120	942
25	3975	878·7	4301	943
26	4130	953·0	4483	945
27	4287	1031	4668	947
28	4444	1113	4855	949
29	4601	1198	5043	952
30	4760	1288	5234	955
31	4919	1382	5428	958
32	5080	1480	5625	961
33	5242	1583	5824	965
34	5405	1691	6026	969
35	5569	1804	6232	973
36	5735	1923	6441	977
37	5902	2046	6653	982
38	6072	2176	6870	987
39	6242	2312	7090	992
40	6415	2454	7315	997
41	6589	2603	7545	1003
42	6766	2760	7779	1009
43	6945	2923	8019	1015
44	7126	3095	8264	1022
45	7309	3275	8515	1029
46	7495	3465	8772	1036
47	7684	3663	9035	1043
48	7875	3872	9306	1050
49	8069	4091	9583	1058
50	8265	4322	9869	1066
51	8465	4564	10162	1074
52	8668	4820	10465	1083
53	8875	5088	10777	1092
54	9084	5372	11098	1101
55	9298	5671	11430	1110
56	9514	5986	11774	1119
57	9735	6319	12129	1128
58	9959	6671	12497	1138
59	10187	7043	12879	1148
60	10419	7437	13275	1158

$\gamma = 0·45$

ϕ	(X)	(Y)	(T)	(V)
32°	11924	4776	8344	3276
31	10463	3879	7754	2592
30	9448	3281	7265	2257
29	8646	2826	6836	2044
28	7972	2460	6445	1892
27	7387	2155	6085	1775
26	6866	1895	5748	1682
25	6395	1670	5430	1605
24	5964	1474	5129	1540
23	5565	1300	4841	1484
22	5194	1147	4566	1435
21	4845	1009	4301	1391
20	4517	886·5	4045	1353

$\gamma = 0·50$

ϕ	(X)	(Y)	(T)	(V)
29°	9841	3387	7211	2617
28	8820	2832	6731	2252
27	8026	2419	6311	2028
26	7364	2089	5932	1871
25	6794	1816	5582	1752
24	6288	1586	5255	1658
23	5831	1387	4947	1580
22	5414	1214	4655	1515
21	5028	1062	4376	1459
20	4669	927·8	4109	1410
19	4333	808·7	3852	1367
18	4016	702·6	3604	1329
17	3716	607·9	3364	1295
16	3430	523·4	3131	1264
15	3158	447·8	2905	1235
14	2897	380·3	2685	1210
13	2647	320·2	2470	1186
12	2406	266·7	2260	1165
11	2173	219·4	2054	1145

XVI. (*continued*).

$\gamma=0·50$				
ϕ	(X)	(Y)	(T)	(V)
10°	1948	177·6	1852	1126
9	1730	141·1	1655	1109
8	1518	109·5	1460	1093
7	1312	82·4	1269	1079
6	1112	59·6	1081	1065
5	916	40·7	895	1052
4	725	25·7	712	1040
3	539	14·2	531	1029
2	356	6·3	352	1019
1	176	1·5	175	1009
0	0	0	0	1000
1	173	1·5	174	992
2	343	6·0	346	984
3	511	13·3	517	976
4	676	23·4	688	970
5	839	36·2	857	963
6	1000	51·7	1025	957
7	1159	69·8	1193	952
8	1317	90·5	1360	947
9	1472	113·8	1527	943
10	1627	139·7	1693	938
11	1780	168·0	1859	935
12	1932	198·9	2026	931
13	2082	232·3	2192	928
14	2232	268·3	2358	925
15	2381	306·9	2525	923
16	2530	348·0	2692	921
17	2677	391·8	2859	919
18	2825	438·2	3027	918
19	2971	487·3	3196	917
20	3118	539·1	3366	916
21	3264	593·8	3536	915
22	3410	651·3	3708	915
23	3556	711·8	3881	915
24	3702	775·4	4055	915
25	3848	842·0	4230	916
26	3995	911·8	4407	916
27	4142	985·0	4586	918
28	4289	1062	4767	919
29	4436	1142	4949	920
30	4585	1226	5134	922

$\gamma=0·50$				
ϕ	(X)	(Y)	(T)	(V)
31°	4733	1313	5321	925
32	4883	1405	5511	927
33	5033	1501	5703	930
34	5184	1601	5898	932
35	5337	1705	6095	936
36	5490	1815	6296	939
37	5644	1929	6501	943
38	5800	2049	6708	947
39	5957	2173	6920	951
40	6116	2304	7136	955
41	6276	2441	7355	960
42	6437	2584	7579	965
43	6600	2733	7808	970
44	6765	2890	8042	975
45	6932	3054	8282	981
46	7101	3226	8526	986
47	7272	3406	8777	992
48	7445	3594	9035	999
49	7620	3792	9298	1005
50	7798	4000	9570	1012
51	7978	4219	9848	1019
52	8160	4448	10135	1026
53	8345	4689	10430	1033
54	8533	4943	10734	1041
55	8723	5210	11048	1048
56	8916	5491	11373	1056
57	9112	5787	11708	1064
58	9312	6100	12055	1072
59	9514	6430	12414	1081
60	9719	6779	12788	1089

$\gamma=0·60$				
ϕ	(X)	(Y)	(T)	(V)
26°	9334	2908	6533	2970
25	8120	2327	6024	2379
24	7261	1936	5599	2081
23	6577	1638	5222	1890
22	6000	1399	4879	1752
21	5497	1200	4560	1647

XVI. (*continued*).

$\gamma = 0{\cdot}60$					$\gamma = 0{\cdot}60$				
ϕ	(X)	(Y)	(T)	(V)	ϕ	(X)	(Y)	(T)	(V)
20°	5048	1033	4261	1563	21°	3179	573·5	3489	893
19	4642	888·5	3979	1493	22	3318	628·3	3656	892
18	4268	763·5	3710	1434	23	3457	685·8	3824	891
17	3923	654·4	3452	1383	24	3595	746·0	3994	891
16	3600	558·8	3204	1338	25	3734	809·2	4165	891
15	3296	474·6	2966	1299	26	3872	875·2	4337	891
14	3010	400·5	2735	1264	27	4011	944·3	4511	891
13	2738	335·2	2510	1233	28	4150	1017	4686	892
12	2479	277·7	2293	1204	29	4289	1092	4864	893
11	2231	227·3	2081	1179	30	4428	1171	5043	894
10	1993	183·3	1874	1155	31	4568	1253	5224	895
9	1765	145·0	1671	1134	32	4708	1339	5408	897
8	1545	112·1	1473	1114	33	4849	1429	5593	899
7	1332	84·0	1278	1096	34	4990	1522	5782	901
6	1126	60·5	1087	1078	35	5132	1620	5973	904
5	925	41·3	900	1063	36	5275	1722	6167	906
4	731	25·9	715	1049	37	5419	1828	6364	909
3	542	14·4	533	1035	38	5564	1939	6564	912
2	357	6·3	353	1023	39	5709	2055	6768	916
1	176	1·6	176	1011	40	5856	2176	6976	919
0	0	0	0	1000					
1	173	1·5	174	990	41	6004	2303	7187	923
2	342	5·9	346	981	42	6154	2435	7402	927
3	508	13·2	516	972	43	6304	2573	7622	931
4	672	23·2	685	964	44	6456	2717	7847	936
5	833	35·8	853	956	45	6610	2868	8077	941
6	991	51·1	1020	949	46	6765	3026	8311	945
7	1147	68·9	1187	942	47	6922	3192	8552	951
8	1301	89·1	1352	936	48	7081	3365	8798	956
9	1453	111·8	1517	931	49	7241	3546	9051	962
10	1603	137·0	1681	926	50	7403	3736	9310	967
11	1752	164·6	1845	921	51	7568	3935	9576	973
12	1899	194·5	2008	916	52	7734	4144	9850	979
13	2045	226·9	2172	913	53	7902	4364	10131	986
14	2190	261·6	2335	909	54	8073	4595	10422	992
15	2334	298·8	2499	906	55	8246	4837	10721	999
16	2476	338·3	2663	903	56	8421	5092	11030	1006
17	2618	380·3	2827	900	57	8599	5361	11349	1013
18	2759	424·8	2991	898	58	8779	5644	11679	1020
19	2900	471·8	3156	896	59	8962	5942	12021	1027
20	3040	521·4	3322	894	60	9147	6257	12375	1034

XVI. *(continued).*

$\gamma = 0{\cdot}70$				
ϕ	(X)	(Y)	(T)	(V)
23°	8132	2201	5692	2856
22	7012	1736	5215	2283
21	6221	1424	4815	1997
20	5590	1188	4461	1814
19	5059	1000	4138	1683
18	4595	844·6	3838	1582
17	4180	714·0	3556	1501
16	3805	602·7	3289	1435
15	3460	507·0	3035	1378
14	3140	424·2	2791	1330
13	2841	352·5	2556	1288
12	2561	290·2	2329	1250
11	2295	236·2	2109	1217
10	2043	189·5	1896	1187
9	1803	149·2	1689	1160
8	1573	114·8	1486	1136
7	1352	85·8	1288	1113
6	1140	61·6	1094	1093
5	935	41·8	904	1074
4	737	26·2	718	1057
3	545	14·5	534	1041
2	358	6·3	354	1026
1	177	1·6	176	1013
0	0	0	0	1000
1	173	1·5	174	988
2	341	5·9	345	977
3	506	13·1	515	967
4	668	23·0	683	958
5	826	35·5	850	949
6	982	50·5	1016	941
7	1135	67·9	1180	933
8	1286	87·8	1344	926
9	1434	110·0	1507	919
10	1581	134·5	1669	913
11	1726	161·3	1831	908
12	1869	190·4	1992	903
13	2010	221·7	2153	898
14	2150	255·4	2313	894
15	2289	291·2	2474	890
16	2426	329·4	2635	886
17	2563	369·8	2796	883
18	2699	412·6	2957	880
19	2833	457·6	3119	877
20	2967	505·1	3281	875

$\gamma = 0{\cdot}70$				
ϕ	(X)	(Y)	(T)	(V)
21°	3101	555·0	3444	873
22	3233	607·3	3608	872
23	3366	662·1	3772	870
24	3498	719·5	3938	869
25	3630	779·6	4104	869
26	3761	842·3	4272	868
27	3893	907·9	4442	868
28	4024	976·3	4612	868
29	4156	1048	4785	868
30	4287	1122	4959	869
31	4419	1200	5135	870
32	4551	1281	5313	871
33	4684	1365	5494	872
34	4817	1453	5676	874
35	4950	1545	5861	876
36	5085	1641	6049	878
37	5219	1741	6240	880
38	5355	1845	6434	882
39	5491	1953	6631	885
40	5628	2066	6832	888
41	5766	2184	7036	891
42	5906	2307	7244	895
43	6046	2436	7456	898
44	6187	2570	7673	902
45	6331	2710	7894	906
46	6474	2857	8120	910
47	6620	3010	8352	915
48	6766	3170	8589	920
49	6915	3338	8832	925
50	7065	3514	9081	930
51	7216	3698	9337	935
52	7370	3891	9599	940
53	7525	4093	9870	946
54	7682	4305	10148	952
55	7841	4528	10435	957
56	8002	4762	10731	963
57	8165	5009	11037	970
58	8330	5268	11353	976
59	8498	5541	11680	982
60	8667	5829	12019	989

XVI. (*continued*).

$\gamma=0.80$					$\gamma=0.80$				
ϕ	(X)	(Y)	(T)	(V)	ϕ	(X)	(Y)	(T)	(V)
20°	6536	1476	4764	2393	21°	3028	538·0	3402	855
19	5695	1178	4358	2032	22	3155	588·1	3562	853
18	5051	962·6	4004	1820	23	3282	640·6	3723	851
17	4521	795·0	3685	1675	24	3408	695·4	3885	850
16	4063	659·5	3391	1567	25	3534	752·7	4048	848
15	3659	547·2	3115	1481	26	3659	812·6	4212	847
14	3294	452·9	2854	1412	27	3785	875·0	4377	847
13	2961	372·8	2606	1353	28	3910	940·1	4544	846
12	2653	304·5	2369	1304	29	4035	1008	4712	846
11	2366	246·2	2141	1261	30	4160	1079	4882	846
10	2097	196·3	1920	1223	31	4285	1152	5053	847
9	1844	153·8	1707	1190	32	4410	1229	5226	847
8	1603	117·8	1500	1160	33	4535	1309	5402	848
7	1374	87·6	1298	1133	34	4661	1392	5579	849
6	1155	62·6	1101	1108	35	4787	1479	5759	851
5	945	42·4	909	1086	36	4914	1569	5942	852
4	743	26·5	721	1066	37	5041	1663	6127	854
3	548	14·6	536	1047	38	5168	1761	6315	856
2	360	6·3	354	1030	39	5297	1863	6507	858
1	177	1·6	176	1015	40	5426	1970	6701	861
0	0	0	0	1000					
1	172	1·5	173	987	41	5555	2080	6899	864
2	340	5·9	345	974	42	5686	2196	7101	867
3	504	13·0	514	963	43	5818	2316	7306	870
4	663	22·8	681	952	44	5950	2442	7516	873
5	820	35·1	847	942	45	6084	2573	7730	877
6	973	49·9	1011	933	46	6218	2710	7948	880
7	1124	67·0	1174	924	47	6354	2854	8172	884
8	1271	86·4	1336	916	48	6491	3003	8401	888
9	1417	108·2	1497	909	49	6630	3160	8636	893
10	1560	132·1	1657	902	50	6769	3323	8876	897
11	1701	158·2	1817	896	51	6911	3495	9123	902
12	1840	186·5	1976	890	52	7053	3674	9377	907
13	1977	216·9	2134	884	53	7198	3862	9637	912
14	2113	249·5	2293	879	54	7343	4059	9906	917
15	2247	284·2	2451	875	55	7490	4266	10182	922
16	2380	321·0	2609	870	56	7640	4483	10467	928
17	2511	360·0	2767	867	57	7791	4712	10761	933
18	2642	401·2	2925	863	58	7944	4952	11065	939
19	2771	444·5	3084	860	59	8099	5204	11380	945
20	2900	490·1	3243	857	60	8256	5471	11706	951

XVI. (*continued*).

$\gamma = 0·90$				
ϕ	(X)	(Y)	(T)	(V)
18°	5812	1169	4247	2331
17	5016	917·9	3857	1973
16	4410	738·3	3518	1766
15	3911	599·7	3211	1624
14	3482	488·5	2929	1518
13	3102	397·2	2664	1435
12	2759	321·2	2413	1368
11	2446	257·5	2175	1312
10	2157	203·9	1946	1264
9	1888	158·8	1727	1222
8	1635	121·0	1514	1186
7	1396	89·6	1308	1153
6	1170	63·8	1108	1124
5	955	43·0	914	1098
4	749	26·8	723	1075
3	551	14·7	537	1054
2	361	6·4	355	1034
1	177	1·6	176	1016
0	0	0	0	1000
1	172	1·5	173	985
2	339	5·9	344	971
3	501	12·9	512	958
4	659	22·6	679	946
5	814	34·8	844	935
6	965	49·3	1007	925
7	1113	66·1	1168	916
8	1257	85·2	1329	907
9	1399	106·4	1488	898
10	1539	129·8	1646	891
11	1677	155·3	1804	884
12	1812	182·8	1961	877
13	1945	212·4	2117	871
14	2077	244·0	2273	866
15	2207	277·6	2428	861
16	2335	313·2	2584	856
17	2463	350·9	2739	852
18	2589	390·6	2895	848
19	2714	432·4	3050	844
20	2838	476·3	3206	841

$\gamma = 0·90$				
ϕ	(X)	(Y)	(T)	(V)
21°	2961	522·3	3363	838
22	3083	570·4	3520	836
23	3204	620·8	3677	834
24	3325	673·4	3836	832
25	3446	728·3	3995	830
26	3566	785·5	4156	829
27	3685	845·2	4317	828
28	3805	907·3	4480	827
29	3924	972·0	4644	826
30	4043	1039	4810	826
31	4162	1110	4977	826
32	4281	1183	5146	826
33	4400	1259	5317	827
34	4520	1338	5490	828
35	4640	1420	5666	829
36	4760	1505	5843	830
37	4880	1594	6024	831
38	5001	1687	6207	833
39	5122	1784	6392	835
40	5244	1884	6582	837
41	5366	1989	6774	839
42	5490	2098	6970	842
43	5614	2211	7169	844
44	5738	2330	7373	847
45	5864	2453	7580	850
46	5991	2582	7793	854
47	6119	2717	8009	857
48	6247	2858	8231	861
49	6377	3004	8459	865
50	6508	3158	8692	869
51	6641	3319	8931	873
52	6775	3487	9176	877
53	6910	3663	9428	882
54	7046	3847	9688	887
55	7184	4041	9955	892
56	7324	4244	10231	897
57	7465	4457	10515	902
58	7607	4681	10809	907
59	7752	4917	11112	912
60	7898	5165	11427	918

XVI. (*continued*).

$\gamma = 1{\cdot}0$				
ϕ	(X)	(Y)	(T)	(V)
17°	5941	1161	4127	2763
16	4936	862·7	3691	2132
15	4254	673·4	3333	1844
14	3720	534·9	3018	1667
13	3272	427·4	2730	1542
12	2883	341·1	2464	1447
11	2537	270·6	2213	1372
10	2224	212·5	1975	1310
9	1936	164·3	1748	1258
8	1670	124·5	1530	1214
7	1421	91·7	1319	1175
6	1187	65·0	1116	1142
5	965	43·7	919	1111
4	755	27·1	726	1085
3	554	14·8	539	1060
2	362	6·4	356	1038
1	178	1·6	176	1018
0	0	0	0	1000
1	172	1·5	173	983
2	338	5·8	343	968
3	499	12·9	511	954
4	655	22·4	677	941
5	808	34·4	841	929
6	957	48·7	1002	918
7	1102	65·3	1163	907
8	1244	84·0	1321	898
9	1383	104·8	1479	889
10	1520	127·6	1636	880
11	1654	152·5	1791	873
12	1785	179·3	1946	866
13	1915	208·1	2100	859
14	2043	238·8	2254	853
15	2169	271·4	2407	847
16	2294	305·9	2560	842
17	2417	342·4	2713	838
18	2539	380·8	2866	833
19	2659	421·2	3019	829
20	2779	463·5	3172	826

$\gamma = 1{\cdot}0$				
ϕ	(X)	(Y)	(T)	(V)
21°	2898	507·8	3326	823
22	3015	554·2	3480	820
23	3132	602·6	3634	817
24	3248	653·1	3790	815
25	3364	705·8	3946	813
26	3479	760·7	4103	811
27	3594	817·9	4261	810
28	3708	877·4	4420	809
29	3822	939·3	4581	808
30	3936	1004	4743	808
31	4050	1071	4906	807
32	4163	1140	5071	807
33	4277	1213	5238	807
34	4391	1288	5407	808
35	4505	1367	5578	808
36	4619	1448	5752	809
37	4733	1533	5928	810
38	4848	1621	6106	812
39	4964	1712	6287	813
40	5079	1808	6471	815
41	5195	1907	6659	817
42	5312	2010	6849	819
43	5430	2118	7044	822
44	5548	2230	7242	824
45	5667	2347	7444	827
46	5787	2469	7650	830
47	5907	2596	7861	833
48	6029	2729	8077	837
49	6152	2868	8297	840
50	6275	3013	8524	844
51	6400	3164	8756	848
52	6526	3322	8994	852
53	6653	3488	9239	856
54	6782	3662	9491	860
55	6912	3844	9750	865
56	7043	4035	10017	869
57	7176	4235	10293	874
58	7310	4446	10577	879
59	7445	4667	10872	884
60	7582	4900	11177	889

XVI. (*continued*).

$\gamma = 1·1$				
ϕ	(X)	(Y)	(T)	(V)
15°	4789	793·3	3502	2272
14	4044	600·3	3130	1898
13	3487	466·5	2810	1688
12	3032	365·4	2521	1548
11	2642	286·1	2255	1445
10	2299	222·3	2006	1365
9	1989	170·5	1770	1300
8	1707	128·3	1546	1245
7	1446	93·9	1331	1199
6	1204	66·3	1124	1160
5	976	44·3	924	1125
4	761	27·4	729	1094
3	558	14·9	541	1067
2	364	6·4	356	1042
1	178	1·6	176	1020
0	0	0	0	1000
1	171	1·5	173	982
2	337	5·8	343	965
3	497	12·8	510	950
4	652	22·3	675	935
5	802	34·1	837	922
6	949	48·2	998	910
7	1091	64·5	1157	899
8	1231	82·8	1314	889
9	1367	103·2	1470	879
10	1501	125·5	1625	870
11	1632	149·8	1779	862
12	1760	176·0	1932	855
13	1887	204·0	2084	848
14	2011	233·9	2235	841
15	2134	265·6	2387	835
16	2255	299·1	2537	830
17	2374	334·4	2688	825
18	2492	371·6	2838	820
19	2609	410·7	2989	816
20	2724	451·6	3139	812
21	2839	494·4	3290	808
22	2952	539·1	3442	805
23	3065	585·7	3593	802
24	3177	634·4	3746	800
25	3288	685·1	3899	797

$\gamma = 1·1$				
ϕ	(X)	(Y)	(T)	(V)
26°	3399	737·9	4053	795
27	3509	792·8	4208	794
28	3619	850·0	4364	792
29	3728	909·4	4521	791
30	3837	971·2	4680	791
31	3946	1035	4840	790
32	4055	1102	5001	790
33	4164	1171	5165	790
34	4273	1243	5330	790
35	4382	1318	5497	790
36	4491	1396	5667	791
37	4600	1477	5839	792
38	4709	1561	6013	793
39	4819	1648	6190	794
40	4929	1739	6370	796
41	5040	1834	6552	797
42	5151	1932	6738	799
43	5263	2035	6928	801
44	5375	2141	7121	804
45	5488	2252	7318	806

$\gamma = 1·2$				
ϕ	(X)	(Y)	(T)	(V)
14°	4553	707·6	3287	2355
13	3777	520·8	2909	1914
12	3217	396·4	2589	1685
11	2766	304·6	2303	1537
10	2384	233·6	2040	1429
9	2048	177·4	1795	1347
8	1747	132·4	1564	1280
7	1474	96·3	1343	1225
6	1222	67·6	1132	1179
5	987	45·0	929	1139
4	768	27·7	733	1104
3	561	15·0	542	1074
2	365	6·5	357	1047
1	178	1·6	176	1022
0	0	0	0	1000

XVI. (*continued*).

$\gamma = 1{\cdot}2$

ϕ	(X)	(Y)	(T)	(V)
1°	171	1·5	173	980
2	336	5·8	342	962
3	494	12·7	509	945
4	648	22·1	673	930
5	796	33·8	834	916
6	941	47·7	994	903
7	1081	63·7	1152	891
8	1218	81·7	1307	880
9	1352	101·7	1462	870
10	1483	123·5	1615	861
11	1611	147·3	1767	852
12	1736	172·8	1918	844
13	1859	200·1	2068	837
14	1981	229·2	2218	830
15	2100	260·0	2367	823
16	2217	292·6	2515	818
17	2333	326·9	2664	812
18	2447	363·0	2812	807
19	2561	400·8	2960	803
20	2672	440·4	3108	798
21	2783	481·8	3257	795
22	2893	525·0	3405	791
23	3002	570·1	3555	788
24	3110	617·1	3704	785
25	3217	666·0	3855	783
26	3324	716·8	4006	781
27	3430	769·7	4158	779
28	3535	824·7	4311	777
29	3640	881·9	4465	776
30	3745	941·2	4621	775
31	3850	1003	4778	774
32	3955	1067	4936	774
33	4059	1133	5096	773
34	4163	1203	5258	773
35	4268	1274	5422	773
36	4372	1349	5587	774
37	4477	1426	5755	774
38	4582	1507	5926	775
39	4687	1590	6099	776
40	4792	1677	6275	778
41	4898	1767	6453	779
42	5004	1861	6635	781
43	5111	1959	6820	783
44	5218	2061	7009	785
45	5326	2167	7201	787

$\gamma = 1{\cdot}3$

ϕ	(X)	(Y)	(T)	(V)
13°	4222	607·8	3046	2325
12	3460	438·4	2673	1889
11	2917	327·7	2359	1657
10	2482	246·9	2079	1508
9	2114	185·2	1822	1401
8	1792	137·0	1582	1320
7	1503	99·0	1356	1254
6	1241	69·0	1141	1200
5	999	45·7	934	1154
4	775	28·1	736	1115
3	565	15·2	544	1081
2	366	6·5	358	1051
1	179	1·6	177	1024
0	0	0	0	1000
1	171	1·5	173	978
2	335	5·8	342	959
3	492	12·6	508	941
4	644	21·9	671	925
5	791	33·5	831	910
6	933	47·2	990	896
7	1071	62·9	1146	884
8	1206	80·6	1301	872
9	1337	100·2	1454	862
10	1465	121·6	1605	852
11	1590	144·8	1756	843
12	1713	169·8	1905	834
13	1833	196·5	2053	826
14	1951	224·8	2201	819
15	2067	254·8	2348	812
16	2182	286·5	2495	806
17	2294	319·9	2641	800
18	2405	354·9	2787	795
19	2515	391·6	2933	790
20	2624	430·0	3079	786
21	2731	470·1	3225	782
22	2837	511·9	3371	778
23	2942	555·5	3518	775
24	3047	600·9	3665	772
25	3150	648·2	3813	769
26	3253	697·3	3961	767
27	3356	748·3	4111	765
28	3458	801·4	4261	763
29	3559	856·4	4412	762
30	3660	913·6	4565	760

XVI. (*continued*).

$\gamma = 1{\cdot}3$

ϕ	(X)	(Y)	(T)	(V)
31°	3761	973·0	4719	759
32	3861	1035	4874	759
33	3962	1099	5031	758
34	4062	1165	5190	758
35	4162	1234	5350	758
36	4263	1305	5513	758
37	4363	1380	5678	759
38	4464	1457	5845	759
39	4564	1537	6014	760
40	4665	1620	6186	761
41	4767	1707	6361	763
42	4868	1797	6539	764
43	4971	1891	6720	766
44	5073	1988	6905	768
45	5176	2089	7093	770

$\gamma = 1{\cdot}4$

ϕ	(X)	(Y)	(T)	(V)
12°	3817	502·1	2784	2250
11	3110	357·8	2426	1827
10	2599	263·0	2123	1608
9	2189	194·2	1852	1466
8	1841	142·1	1602	1364
7	1535	101·8	1370	1285
6	1261	70·5	1150	1222
5	1012	46·5	940	1170
4	782	28·4	739	1126
3	568	15·3	546	1088
2	368	6·5	358	1055
1	179	1·6	177	1026
0	0	0	0	1000
1	171	1·5	173	977
2	333	5·7	341	956
3	490	12·6	507	937
4	640	21·7	669	920
5	785	33·2	829	904

$\gamma = 1{\cdot}4$

ϕ	(X)	(Y)	(T)	(V)
6°	926	46·7	986	890
7	1062	62·2	1141	877
8	1194	79·6	1294	865
9	1323	98·8	1446	853
10	1448	119·8	1596	843
11	1571	142·5	1745	833
12	1691	166·9	1892	825
13	1808	193·0	2039	816
14	1923	220·6	2185	809
15	2037	249·9	2330	802
16	2148	280·8	2475	795
17	2258	313·2	2619	790
18	2366	347·3	2763	784
19	2472	382·9	2907	779
20	2577	420·2	3050	774
21	2681	459·1	3194	770
22	2784	499·7	3338	766
23	2886	541·9	3483	763
24	2987	585·9	3628	760
25	3088	631·6	3773	757
26	3187	679·1	3919	754
27	3286	728·4	4066	752
28	3385	779·7	4214	750
29	3483	832·8	4362	748
30	3580	888·0	4512	747
31	3678	945·3	4664	746
32	3774	1005	4816	745
33	3871	1066	4970	744
34	3968	1130	5126	744
35	4064	1197	5283	744
36	4161	1266	5443	744
37	4258	1337	5604	744
38	4354	1411	5768	745
39	4451	1488	5934	745
40	4548	1568	6103	746
41	4646	1652	6275	747
42	4743	1738	6449	749
43	4841	1828	6626	750
44	4940	1921	6807	752
45	5039	2019	6991	754

XVI. (*continued*).

$\gamma = 1·5$				
ϕ	(X)	(Y)	(T)	(V)
11°	3373	400·5	2511	2099
10	2743	283·2	2174	1741
9	2275	204·8	1885	1545
8	1895	147·8	1624	1415
7	1569	104·9	1384	1320
6	1282	72·2	1159	1246
5	1025	47·3	946	1187
4	789	28·8	742	1137
3	572	15·4	547	1095
2	369	6·6	359	1059
1	179	1·6	177	1028
0	0	0	0	1000
1	170	1·5	172	975
2	332	5·7	341	953
3	488	12.5	505	933
4	637	21·6	667	915
5	780	32·9	826	898
6	918	46·2	982	883
7	1053	61·5	1136	870
8	1183	78·6	1288	857
9	1309	97·5	1438	845
10	1432	118·1	1587	835
11	1552	140·3	1734	825
12	1669	164·2	1880	815
13	1784	189·6	2025	807
14	1897	216·6	2169	799
15	2007	245·2	2312	792
16	2116	275·3	2455	785
17	2223	306·9	2598	779
18	2328	340·1	2740	773
19	2431	374·7	2881	768
20	2534	411·0	3023	763
21	2635	448·8	3165	759
22	2735	488·1	3307	755
23	2834	529·1	3449	751
24	2932	571·8	3592	748
25	3029	616·1	3735	745
26	3125	662·1	3879	742
27	3221	709·9	4023	740
28	3316	759·4	4169	738
29	3411	810·9	4315	736
30	3505	864·3	4462	734

$\gamma = 1·5$				
ϕ	(X)	(Y)	(T)	(V)
31°	3599	919·6	4611	733
32	3693	977·0	4761	732
33	3787	1037	4912	731
34	3880	1098	5065	731
35	3973	1162	5220	731
36	4066	1229	5377	731
37	4159	1298	5535	731
38	4253	1369	5696	731
39	4346	1444	5859	732
40	4439	1521	6025	732
41	4533	1601	6193	733
42	4627	1684	6364	735
43	4722	1770	6538	736
44	4816	1860	6715	738
45	4911	1954	6896	739

$\gamma = 1·6$				
ϕ	(X)	(Y)	(T)	(V)
10°	2927	309·8	2236	1933
9	2377	217·5	1922	1644
8	1955	154·3	1648	1475
7	1606	108·3	1399	1359
6	1305	73·9	1169	1272
5	1038	48·2	952	1204
4	797	29·1	746	1149
3	576	15·6	549	1103
2	371	6·6	360	1064
1	180	1·6	177	1030
0	0	0	0	1000
1	170	1·5	172	974
2	331	5·7	340	950
3	485	12·4	504	929
4	633	21·4	665	910
5	775	32·6	823	893
6	911	45·7	978	877
7	1044	60·8	1131	863
8	1171	77·6	1282	850
9	1296	96·2	1430	838
10	1416	116·4	1578	826

XVI. (*continued*).

$\gamma = 1·6$				
ϕ	(X)	(Y)	(T)	(V)
11°	1534	138·2	1723	816
12	1649	161·5	1868	807
13	1761	186·4	2011	798
14	1871	212·9	2154	790
15	1979	240·7	2296	782
16	2085	270·1	2437	776
17	2189	300·9	2577	769
18	2292	333·2	2717	763
19	2393	367·0	2857	758
20	2492	402·3	2997	753
21	2590	439·0	3137	748
22	2688	477·3	3277	744
23	2784	517·1	3417	740
24	2879	558·5	3558	737
25	2973	601·5	3699	734
26	3067	646·2	3840	731
27	3160	692·5	3983	729
28	3252	740·6	4126	726
29	3344	790·4	4270	724
30	3435	842·1	4415	723
31	3526	895·7	4561	721
32	3617	951·2	4709	720
33	3707	1009	4858	719
34	3798	1069	5008	719
35	3888	1131	5160	718
36	3978	1195	5314	718
37	4068	1261	5470	718
38	4158	1330	5628	718
39	4248	1402	5788	719
40	4338	1476	5951	720
41	4429	1554	6116	720
42	4519	1634	6284	721
43	4610	1717	6455	723
44	4702	1804	6629	724
45	4793	1894	6807	726

$\gamma = 1·7$				
ϕ	(X)	(Y)	(T)	(V)
10°	3186	348·4	2316	2254
9	2501	233·2	1966	1775
8	2025	161·9	1675	1546
7	1647	112·1	1416	1403
6	1329	75·8	1179	1301
5	1052	49·0	958	1223
4	804	29·5	749	1162
3	579	15·7	551	1111
2	372	6·6	361	1068
1	180	1·6	177	1032
0	0	0	0	1000

$\gamma = 1·8$				
ϕ	(X)	(Y)	(T)	(V)
9°	2658	253·7	2018	1961
8	2105	170·7	1704	1634
7	1693	116·3	1434	1453
6	1356	77·8	1190	1332
5	1067	50·0	964	1243
4	813	29·9	753	1175
3	583	15·9	553	1119
2	374	6·7	361	1073
1	180	1·6	177	1034
0	0	0	0	1000
1	169	1·5	172	971
2	329	5·6	339	945
3	481	12·3	502	922
4	626	21·1	661	901
5	765	32·0	817	882
6	898	44·8	971	865
7	1026	59·4	1121	850
8	1150	75·8	1270	836
9	1270	93·7	1416	823
10	1387	113·2	1560	811

XVI. (*continued*).

$\gamma = 1·8$

φ	(x)	(y)	(t)	(v)
11°	1500	134·2	1703	800
12	1610	156·6	1845	790
13	1718	180·5	1986	781
14	1823	205·8	2125	773
15	1926	232·4	2263	765
16	2027	260·5	2401	757
17	2127	289·9	2539	751
18	2224	320·6	2675	745
19	2320	352·7	2812	739
20	2415	386·2	2948	734
21	2508	421·1	3084	729
22	2600	457·4	3221	724
23	2691	495·1	3357	720
24	2782	534·3	3494	717
25	2871	575·0	3631	713
26	2959	617·1	3769	710
27	3047	660·9	3907	708
28	3134	706·2	4046	705
29	3221	753·2	4186	703
30	3307	801·9	4327	701
31	3392	852·3	4469	700
32	3478	904·6	4612	698
33	3563	958·8	4756	697
34	3647	1015	4902	697
35	3732	1073	5049	696
36	3816	1133	5198	696
37	3901	1196	5349	695
38	3985	1260	5502	695
39	4070	1328	5658	696
40	4154	1397	5815	696
41	4239	1470	5975	697
42	4324	1545	6137	698
43	4409	1623	6302	699
44	4494	1704	6471	700
45	4580	1788	6642	701

$\gamma = 1·9$

φ	(x)	(y)	(t)	(v)
9°	2874	282·7	2084	2262
8	2200	181·4	1738	1746
7	1743	121·0	1453	1511
6	1384	80·0	1201	1366
5	1083	51·0	971	1265
4	821	30·3	757	1188
3	587	16·0	554	1127
2	375	6·7	362	1078
1	181	1·6	178	1036
0	0	0	0	1000

$\gamma = 2·0$

φ	(x)	(y)	(t)	(v)
8°	2316	194·8	1777	1896
7	1799	126·5	1474	1579
6	1414	82·4	1214	1404
5	1099	52·0	978	1288
4	829	30·7	761	1202
3	591	16·2	556	1136
2	377	6·8	363	1082
1	181	1·6	178	1038
0	0	0	0	1000
1	169	1·5	172	968
2	327	5·6	338	939
3	477	12·1	500	914
4	619	20·8	658	892
5	755	31·5	812	872
6	885	44·0	963	854
7	1010	58·2	1112	838
8	1130	74·0	1258	823
9	1246	91·4	1402	809
10	1359	110·2	1544	797

XVI. (*continued*).

$\gamma = 2 \cdot 0$

ϕ	(X)	(Y)	(T)	(V)
11°	1468	130·5	1684	786
12	1574	152·1	1823	775
13	1678	175·0	1961	766
14	1779	199·3	2098	757
15	1878	224·8	2233	749
16	1974	251·7	2368	741
17	2069	279·8	2502	734
18	2163	309·2	2636	728
19	2254	339·8	2770	722
20	2344	371·8	2903	716
21	2433	405·0	3036	711
22	2521	439·6	3169	707
23	2608	475·4	3302	702
24	2693	512·7	3435	699
25	2778	551·3	3569	695
26	2862	591·3	3703	692
27	2945	632·8	3837	689
28	3028	675·8	3973	687
29	3110	720·3	4109	684
30	3191	766·4	4246	682
31	3272	814·1	4384	681
32	3353	863·5	4523	679
33	3433	914·7	4663	678
34	3513	967·7	4805	677
35	3593	1023	4948	676
36	3673	1079	5093	676
37	3752	1138	5240	675
38	3832	1199	5389	675
39	3911	1263	5539	675
40	3991	1328	5692	676
41	4071	1396	5847	676
42	4151	1467	6005	677
43	4231	1540	6165	678
44	4311	1617	6328	679
45	4391	1696	6494	680

$\gamma = 2 \cdot 1$

ϕ	(X)	(Y)	(T)	(V)
8°	2467	212·5	1824	2116
7	1864	132·8	1498	1663
6	1447	85·1	1227	1447
5	1117	53·2	986	1312
4	838	31·2	765	1217
3	596	16·3	558	1145
2	379	6·8	364	1087
1	181	1·6	178	1040
0	0	0	0	1000

$\gamma = 2 \cdot 2$

ϕ	(X)	(Y)	(T)	(V)
8°	2680	238·4	1885	2495
7	1940	140·3	1525	1766
6	1483	88·0	1241	1496
5	1135	54·4	993	1339
4	848	31·7	769	1233
3	600	16·5	560	1154
2	380	6·8	364	1092
1	182	1·6	178	1042
0	0	0	0	1000
1	168	1·5	171	965
2	325	5·6	337	934
3	473	12·0	498	907
4	613	20·5	654	883
5	746	31·0	807	862
6	873	43·2	956	843
7	994	57·0	1103	826
8	1111	72·4	1247	811
9	1224	89·2	1389	797
10	1333	107·4	1529	784

XVI. (*continued*).

$\gamma = 2 \cdot 2$

ϕ	(X)	(Y)	(T)	(V)
11°	1438	127·0	1667	772
12	1541	147·9	1803	761
13	1640	170·0	1938	751
14	1738	193·3	2072	742
15	1833	217·9	2205	734
16	1926	243·6	2337	726
17	2017	270·6	2469	719
18	2106	298·8	2600	712
19	2194	328·1	2730	706
20	2280	358·7	2861	700
21	2365	390·4	2991	695
22	2449	423·4	3120	690
23	2531	457·7	3251	686
24	2613	493·2	3381	682
25	2694	530·0	3511	679
26	2774	568·1	3642	675
27	2853	607·6	3773	672
28	2931	648·5	3905	670
29	3009	690·8	4038	667
30	3087	734·7	4172	665
31	3164	780·0	4306	663
32	3240	826·9	4442	662
33	3317	875·5	4579	660
34	3393	925·8	4717	659
35	3468	977·8	4856	658
36	3544	1032	4997	658
37	3619	1088	5140	657
38	3695	1145	5285	657
39	3770	1205	5431	657
40	3845	1267	5580	657
41	3921	1332	5731	658
42	3996	1399	5884	658
43	4072	1468	6040	659
44	4148	1540	6199	660
45	4224	1615	6360	661

$\gamma = 2 \cdot 3$

ϕ	(X)	(Y)	(T)	(V)
7°	2032	149·5	1555	1902
6	1524	91·3	1256	1552
5	1155	55·7	1001	1368
4	858	32·2	773	1249
3	604	16·6	562	1163
2	382	6·9	365	1097
1	182	1·6	178	1044
0	0	0	0	1000

$\gamma = 2 \cdot 4$

ϕ	(X)	(Y)	(T)	(V)
7°	2146	161·3	1591	2093
6	1569	95·0	1273	1617
5	1176	57·1	1010	1400
4	868	32·7	777	1267
3	609	16·8	564	1173
2	383	6·9	366	1102
1	182	1·6	179	1046
0	0	0	0	1000
1	168	1·5	171	962
2	324	5·5	336	929
3	469	11·9	496	900
4	607	20·3	651	875
5	737	30·5	802	853
6	861	42·4	950	833
7	979	55·9	1095	815
8	1093	70·9	1237	799
9	1202	87·2	1376	785
10	1308	104·9	1514	771
11	1410	123·8	1650	759
12	1509	143·9	1784	748
13	1605	165·3	1917	738
14	1699	187·8	2048	728
15	1791	211·5	2179	720
16	1880	236·3	2308	712
17	1968	262·2	2437	705
18	2053	289·2	2566	698
19	2138	317·4	2693	692
20	2220	346·7	2821	686

XVI. (*continued*).

$\gamma = 2{\cdot}4$

φ	(X)	(Y)	(T)	(V)
21°	2302	377·2	2948	681
22	2382	408·8	3075	676
23	2461	441·6	3203	671
24	2539	475·5	3330	667
25	2617	510·7	3455	663
26	2693	547·2	3586	660
27	2769	584·9	3714	657
28	2844	624·0	3843	654
29	2918	664·4	3973	652
30	2992	706·2	4103	650
31	3065	749·4	4235	648
32	3138	794·1	4367	646
33	3211	840·4	4500	645
34	3283	888·3	4635	643
35	3355	937·9	4771	642
36	3427	989·2	4909	642
37	3499	1042	5048	641
38	3571	1097	5189	641
39	3642	1154	5332	641
40	3714	1213	5477	641
41	3786	1275	5624	641
42	3858	1338	5773	641
43	3929	1404	5925	642
44	4001	1472	6080	643
45	4074	1543	6237	644

$\gamma = 2{\cdot}5$

φ	(X)	(Y)	(T)	(V)
7°	2300	177·6	1636	2395
6	1619	99·3	1291	1695
5	1199	58·6	1019	1435
4	878	33·2	782	1285
3	613	17·0	566	1183
2	385	7·0	367	1107
1	183	1·6	179	1048
0	0	0	0	1000

$\gamma = 2{\cdot}6$

φ	(X)	(Y)	(T)	(V)
6°	1678	104·3	1311	1790
5	1223	60·2	1028	1474
4	889	33·8	786	1305
3	618	17·1	569	1193
2	387	7·0	367	1113
1	183	1·6	179	1050
0	0	0	0	1000
1	167	1·4	171	959
2	322	5·5	335	923
3	466	11·7	494	893
4	601	20·0	648	867
5	728	30·0	797	844
6	849	41·7	943	823
7	965	54·8	1086	805
8	1076	69·4	1226	788
9	1182	85·3	1364	773
10	1284	102·4	1500	760
11	1383	120·8	1634	747
12	1479	140·3	1766	736
13	1572	160·9	1896	725
14	1663	182·7	2025	716
15	1751	205·5	2154	707
16	1838	229·4	2281	699
17	1922	254·4	2408	692
18	2005	280·5	2533	685
19	2086	307·6	2659	678
20	2165	335·7	2784	672
21	2243	365·0	2909	667
22	2321	395·4	3033	662
23	2397	426·8	3158	658
24	2471	459·4	3283	653
25	2546	493·2	3408	650
26	2619	528·1	3533	646
27	2691	564·3	3659	643
28	2763	601·7	3785	640
29	2834	640·4	3912	638
30	2905	680·3	4039	635
31	2975	721·7	4168	633
32	3045	764·5	4297	632
33	3115	808·7	4428	630
34	3184	854·5	4560	629
35	3253	901·8	4693	628

XVI. (*continued*).

$\gamma = 2{\cdot}6$

φ	(X)	(Y)	(T)	(V)
36°	3321	950·8	4827	627
37	3390	1002	4963	626
38	3458	1054	5101	626
39	3527	1108	5241	626
40	3595	1165	5382	626
41	3663	1223	5526	626
42	3732	1284	5672	626
43	3800	1346	5820	627
44	3868	1412	5971	628
45	3938	1479	6124	629

$\gamma = 2{\cdot}7$

φ	(X)	(Y)	(T)	(V)
6°	1747	110·2	1334	1912
5	1250	62·0	1039	1517
4	901	34·4	791	1325
3	623	17·3	571	1204
2	389	7·0	368	1118
1	184	1·6	179	1052
0	0	0	0	1000

$\gamma = 2{\cdot}8$

φ	(X)	(Y)	(T)	(V)
6°	1831	117·6	1360	2075
5	1279	64·0	1049	1566
4	913	35·0	796	1348
3	628	17·5	573	1215
2	390	7·1	369	1123
1	184	1·6	179	1055
0	0	0	0	1000
1	167	1·4	171	956
2	320	5·4	334	918
3	462	11·6	492	887
4	595	19·7	644	859
5	720	29·6	793	835

$\gamma = 2{\cdot}8$

φ	(X)	(Y)	(T)	(V)
6°	839	41·0	937	814
7	951	53·8	1078	795
8	1059	68·0	1217	778
9	1163	83·5	1353	762
10	1262	100·1	1486	749
11	1358	118·0	1618	736
12	1451	136·9	1748	724
13	1542	156·9	1877	714
14	1629	177·9	2004	704
15	1715	200·0	2130	695
16	1798	223·1	2255	687
17	1879	247·2	2379	679
18	1959	272·3	2503	672
19	2037	298·5	2626	666
20	2114	325·6	2749	660
21	2189	353·8	2871	655
22	2264	383·0	2994	650
23	2337	413·3	3116	645
24	2409	444·7	3238	641
25	2480	477·1	3361	637
26	2550	510·7	3484	633
27	2620	545·4	3607	630
28	2689	581·3	3731	627
29	2757	618·5	3855	625
30	2825	656·8	3980	622
31	2893	696·5	4106	620
32	2960	737·6	4233	618
33	3026	780·0	4360	617
34	3092	823·8	4489	616
35	3158	869·2	4620	614
36	3224	916·1	4751	614
37	3290	964·7	4884	613
38	3355	1015	5019	612
39	3421	1067	5156	612
40	3486	1121	5294	612
41	3552	1177	5435	612
42	3617	1235	5577	612
43	3683	1295	5722	613
44	3748	1357	5870	614
45	3814	1422	6020	614

XVI. (*continued*).

$\gamma = 2·9$

ϕ	(X)	(Y)	(T)	(V)
6°	1939	127·3	1392	2312
5	1311	66·2	1061	1622
4	926	35·7	802	1371
3	633	17·7	575	1227
2	392	7·1	370	1129
1	184	1·6	179	1057
0	0	0	0	1000

$\gamma = 3·0$

ϕ	(X)	(Y)	(T)	(V)
5°	1346	68·6	1074	1687
4	939	36·4	807	1397
3	639	17·9	578	1239
2	394	7·2	371	1135
1	185	1·6	180	1059
0	0	0	0	1000
1	166	1·4	170	953
2	318	5·4	333	914
3	458	11·5	490	880
4	589	19·5	641	852
5	712	29·1	788	827
6	828	40·3	931	805
7	938	52·9	1071	785
8	1044	66·7	1207	768
9	1144	81·8	1342	752
10	1241	98·0	1473	738
11	1335	115·3	1603	725
12	1425	133·7	1731	714
13	1513	153·1	1858	703
14	1598	173·5	1983	693
15	1680	194·9	2107	684
16	1761	217·2	2230	676
17	1840	240·5	2353	668
18	1917	264·8	2474	661
19	1992	290·1	2595	654
20	2066	316·3	2716	648

$\gamma = 3·0$

ϕ	(X)	(Y)	(T)	(V)
21°	2139	343·5	2836	643
22	2210	371·7	2956	638
23	2281	400·9	3076	633
24	2351	431·1	3197	629
25	2419	462·4	3317	625
26	2487	494·7	3437	622
27	2554	528·1	3558	618
28	2620	562·7	3679	615
29	2686	598·4	3801	613
30	2751	635·3	3924	610
31	2816	673·5	4047	608
32	2881	712·9	4172	606
33	2944	753·7	4297	605
34	3008	795·8	4423	603
35	3072	839·4	4551	602
36	3135	884·5	4680	601
37	3198	931·1	4811	601
38	3261	979·4	4943	600
39	3323	1029	5076	600
40	3386	1081	5212	600
41	3449	1135	5350	600
42	3512	1190	5489	600
43	3575	1248	5631	600
44	3637	1307	5776	601
45	3700	1369	5923	602

$\gamma = 3·1$

ϕ	(X)	(Y)	(T)	(V)
5°	1386	71·4	1088	1764
4	954	37·2	813	1424
3	644	18·1	580	1252
2	396	7·2	372	1141
1	185	1·7	180	1061
0	0	0	0	1000

XVI. (*continued*).

$\gamma = 3·2$				
ϕ	(X)	(Y)	(T)	(V)
5°	1431	74·7	1103	1857
4	969	38·0	819	1454
3	650	18·4	582	1265
2	398	7·3	372	1146
1	185	1·7	180	1063
0	0	0	0	1000
1	166	1·4	170	950
2	316	5·4	332	909
3	455	11·4	488	874
4	584	19·2	638	845
5	704	28·7	784	819
6	818	39·7	925	796
7	926	52·0	1063	777
8	1029	65·5	1198	759
9	1127	80·2	1331	743
10	1221	96·0	1461	728
11	1312	112·8	1589	715
12	1400	130·7	1715	703
13	1485	149·5	1840	693
14	1568	169·3	1964	683
15	1648	190·0	2086	673
16	1726	211·7	2207	665
17	1802	234·3	2327	657
18	1877	257·8	2447	650
19	1950	282·2	2566	644
20	2021	307·6	2685	638
21	2092	333·9	2803	632
22	2161	361·2	2921	627
23	2229	389·4	3039	622
24	2296	418·5	3157	618
25	2362	448·7	3275	614
26	2428	479·9	3394	611
27	2492	512·2	3512	607
28	2556	545·5	3631	604
29	2620	580·0	3751	602
30	2683	615·5	3872	599
31	2745	652·3	3993	597
32	2807	690·3	4115	595
33	2869	729·6	4238	593
34	2930	770·2	4362	592
35	2991	812·1	4487	591

$\gamma = 3·2$				
ϕ	(X)	(Y)	(T)	(V)
36°	3052	855·5	4614	590
37	3113	900·4	4742	589
38	3173	946·8	4871	589
39	3234	994·9	5002	588
40	3294	1045	5135	588
41	3354	1096	5270	588
42	3415	1150	5407	588
43	3475	1205	5546	588
44	3536	1262	5688	589
45	3596	1322	5832	590

$\gamma = 3·3$				
ϕ	(X)	(Y)	(T)	(V)
5°	1484	78·5	1120	1973
4	985	38·9	825	1489
3	656	18·6	585	1278
2	400	7·3	373	1153
1	186	1·7	180	1066
0	0	0	0	1000

$\gamma = 3·4$				
ϕ	(X)	(Y)	(T)	(V)
5°	1547	83·2	1139	2126
4	1002	39·8	831	1522
3	662	18·8	588	1293
2	402	7·4	374	1159
1	186	1·7	180	1068
0	0	0	0	1000
1	165	1·4	170	947
2	314	5·3	331	904
3	451	11·3	486	868
4	578	19·0	635	838
5	697	28·3	779	811

XVI. (*continued*).

$\gamma = 3·4$

φ	(X)	(Y)	(T)	(V)
6°	808	39·1	919	788
7	914	51·1	1056	768
8	1014	64·3	1190	750
9	1110	78·6	1321	734
10	1202	94·0	1449	719
11	1291	110·4	1575	706
12	1376	127·8	1700	694
13	1459	146·1	1823	683
14	1539	165·4	1945	673
15	1617	185·5	2065	664
16	1693	206·6	2185	655
17	1767	228·5	2303	647
18	1839	251·3	2421	640
19	1910	275·0	2538	634
20	1979	299·5	2655	628
21	2047	325·0	2771	622
22	2114	351·4	2887	617
23	2180	378·7	3004	612
24	2245	406·9	3120	608
25	2309	436·1	3236	604
26	2373	466·3	3352	600
27	2435	497·4	3469	597
28	2497	529·6	3586	594
29	2558	562·9	3704	591
30	2619	597·3	3822	589
31	2679	632·8	3941	587
32	2739	669·5	4061	585
33	2799	707·4	4182	583
34	2858	746·5	4304	582
35	2917	787·0	4427	580
36	2975	828·9	4551	579
37	3034	872·1	4677	579
38	3092	916·9	4804	578
39	3150	963·2	4933	578
40	3209	1011	5063	577
41	3267	1061	5196	577
42	3325	1112	5330	577
43	3383	1166	5467	578
44	3441	1221	5606	578
45	3500	1278	5748	579

$\gamma = 3·5$

φ	(X)	(Y)	(T)	(V)
4°	1021	40·8	838	1562
3	668	19·1	590	1308
2	404	7·4	375	1165
1	187	1·7	180	1070
0	0	0	0	1000

$\gamma = 3·6$

φ	(X)	(Y)	(T)	(V)
4°	1041	41·9	846	1605
3	675	19·3	593	1323
2	406	7·5	376	1172
1	187	1·7	181	1072
0	0	0	0	1000
1	165	1·4	170	944
2	313	5·3	330	899
3	448	11·2	484	862
4	573	18·8	632	831
5	689	27·9	775	804
6	799	38·5	914	780
7	902	50·3	1049	760
8	1001	63·2	1181	741
9	1094	77·2	1311	725
10	1184	92·2	1438	710
11	1271	108·2	1562	697
12	1354	125·1	1685	685
13	1434	143·0	1807	674
14	1512	161·7	1927	664
15	1588	181·3	2045	654
16	1662	201·7	2163	646
17	1734	223·0	2280	638
18	1804	245·2	2396	631
19	1872	268·1	2512	624
20	1940	292·0	2627	618
21	2006	316·7	2741	612
22	2071	342·2	2856	607
23	2135	368·7	2970	603
24	2198	396·0	3084	598
25	2260	424·3	3198	594

XVI. (*continued*).

$\gamma = 3·6$

ϕ	(X)	(Y)	(T)	(V)
26°	2321	453·5	3313	591
27	2381	483·7	3428	587
28	2441	514·9	3543	584
29	2501	547·1	3659	582
30	2559	580·3	3775	579
31	2618	614·7	3892	577
32	2675	650·1	4010	575
33	2733	686·8	4129	573
34	2790	724·7	4249	572
35	2847	763·8	4370	571
36	2904	804·2	4492	569
37	2960	846·0	4616	569
38	3017	889·3	4741	568
39	3073	934·0	4867	568
40	3129	980·3	4995	567
41	3185	1028	5126	567
42	3241	1078	5258	567
43	3298	1129	5392	568
44	3354	1183	5529	568
45	3410	1238	5668	568

$\gamma = 3·7$

ϕ	(X)	(Y)	(T)	(V)
4°	1063	43·1	854	1654
3	682	19·6	596	1340
2	408	7·5	377	1178
1	187	1·7	181	1075
0	0	0	0	1000

$\gamma = 3·8$

ϕ	(X)	(Y)	(T)	(V)
4°	1086	44·4	862	1710
3	689	19·8	599	1357
2	410	7·6	378	1185
1	188	1·7	181	1077
0	0	0	0	1000

$\gamma = 3·8$

ϕ	(X)	(Y)	(T)	(V)
1°	164	1·4	169	941
2	311	5·2	329	895
3	445	11·1	482	856
4	568	18·6	629	824
5	682	27·6	771	797
6	790	37·9	909	773
7	891	49·5	1042	752
8	987	62·1	1173	733
9	1079	75·8	1301	717
10	1167	90·5	1426	702
11	1251	106·1	1550	688
12	1332	122·6	1671	676
13	1411	140·0	1791	665
14	1487	158·2	1910	655
15	1560	177·3	2027	645
16	1632	197·2	2143	637
17	1702	217·9	2258	629
18	1770	239·4	2372	622
19	1837	261·7	2486	615
20	1902	284·9	2600	609
21	1967	308·9	2713	604
22	2030	333·7	2825	598
23	2092	359·4	2938	594
24	2153	385·9	3050	589
25	2213	413·3	3163	585
26	2272	441·7	3276	582
27	2331	470·9	3389	578
28	2389	501·2	3502	575
29	2447	532·4	3616	573
30	2503	564·6	3731	570
31	2560	597·9	3846	568
32	2616	632·2	3962	566
33	2672	667·7	4079	564
34	2727	704·4	4197	563
35	2782	742·2	4316	561
36	2837	781·4	4436	560
37	2892	821·9	4558	559
38	2946	863·7	4681	559
39	3001	907·0	4805	558
40	3055	951·8	4932	558
41	3109	998·2	5060	558
42	3164	1046	5190	558
43	3218	1096	5322	558
44	3272	1148	5456	558
45	3327	1201	5593	559

XVI. (*continued*).

$\gamma = 3·9$

ϕ	(x)	(y)	(T)	(v)
4°	1113	45·9	871	1774
3	696	20·1	602	1375
2	412	7·6	379	1192
1	188	1·7	181	1079
0	0	0	0	1000

$\gamma = 4·0$

ϕ	(x)	(y)	(T)	(v)
4°	1142	47·6	881	1848
3	704	20·4	605	1394
2	414	7·7	380	1199
1	188	1·7	181	1082
0	0	0	0	1000
1	164	1·4	169	939
2	309	5·2	329	890
3	442	10·9	481	851
4	563	18·4	626	818
5	676	27·2	767	790
6	781	37·4	903	766
7	881	48·7	1036	744
8	975	61·1	1165	725
9	1064	74·5	1292	709
10	1150	88·8	1416	694
11	1233	104·1	1538	680
12	1312	120·2	1658	668
13	1388	137·2	1776	657
14	1462	154·9	1893	646
15	1534	173·5	2009	637
16	1604	192·9	2123	629
17	1672	213·0	2237	621
18	1739	234·0	2350	613
19	1804	255·7	2462	607
20	1867	278·2	2574	601
21	1930	301·6	2685	595
22	1991	325·7	2796	590
23	2051	350·7	2907	585
24	2110	376·4	3018	581
25	2169	403·1	3129	577
26°	2226	430·6	3241	573
27	2283	459·0	3352	570
28	2340	488·3	3464	567
29	2396	518·6	3576	564
30	2451	549·9	3689	562
31	2506	582·2	3802	559
32	2560	615·5	3917	557
33	2614	649·9	4032	556
34	2668	685·5	4148	554
35	2721	722·2	4265	553
36	2774	760·1	4384	552
37	2827	799·4	4503	551
38	2880	839·9	4624	550
39	2933	881·9	4747	550
40	2986	925·3	4871	549
41	3038	970·2	4997	549
42	3091	1017	5125	549
43	3144	1065	5255	549
44	3196	1115	5387	550
45	3249	1167	5522	550

$\gamma = 4·2$

ϕ	(x)	(y)	(T)	(v)
4°	1212	51·7	903	2047
3	720	21·1	611	1436
2	419	7·8	382	1214
1	189	1·7	182	1087
0	0	0	0	1000

$\gamma = 4·4$

ϕ	(x)	(y)	(T)	(v)
3°	738	21·8	618	1484
2	423	7·9	384	1230
1	190	1·7	182	1091
0	0	0	0	1000

XVI. (*continued*).

$\gamma = 4{\cdot}4$

ϕ	(X)	(Y)	(T)	(V)
1°	163	1·4	169	933
2	306	5·1	327	882
3	435	10·8	477	840
4	554	18·0	621	806
5	663	26·5	759	777
6	765	36·3	893	752
7	860	47·2	1024	730
8	951	59·2	1150	711
9	1037	72·0	1274	694
10	1119	85·7	1396	679
11	1198	100·3	1515	665
12	1273	115·7	1632	652
13	1346	131·9	1748	641
14	1417	148·8	1862	631
15	1485	166·5	1975	622
16	1552	185·0	2087	613
17	1617	204·1	2197	605
18	1680	224·0	2307	598
19	1741	244·7	2417	591
20	1802	266·1	2526	585
21	1861	288·2	2634	580
22	1919	311·1	2742	574
23	1976	334·7	2850	570
24	2032	359·1	2958	565
25	2088	384·3	3066	561
26	2142	410·4	3175	558
27	2196	437·3	3283	554
28	2250	465·0	3392	551
29	2302	493·6	3501	548
30	2355	523·2	3611	546
31	2406	553·7	3721	544
32	2458	585·2	3832	542
33	2509	617·7	3944	540
34	2559	651·3	4057	538
35	2610	685·9	4171	537
36	2660	721·7	4286	536
37	2710	758·7	4402	535
38	2760	797·0	4519	534
39	2810	836·6	4638	534
40	2859	877·5	4759	533
41	2909	919·9	4881	533
42	2958	963·7	5006	533
43	3008	1009	5132	533
44	3058	1056	5260	533
45	3107	1105	5391	534

$\gamma = 4{\cdot}6$

ϕ	(X)	(Y)	(T)	(V)
3°	758	22·6	626	1538
2	428	8·0	386	1246
1	191	1·7	183	1096
0	0	0	0	1000

$\gamma = 4{\cdot}8$

ϕ	(X)	(Y)	(T)	(V)
3°	780	23·5	634	1601
2	433	8·1	388	1263
1	192	1·7	183	1103
0	0	0	0	1000
1	162	1·4	168	928
2	303	5·1	325	874
3	429	10·6	474	830
4	545	17·6	616	795
5	650	25·9	752	765
6	749	35·4	884	739
7	841	45·9	1012	717
8	929	57·4	1136	697
9	1011	69·7	1258	680
10	1090	82·9	1377	665
11	1166	96·9	1493	651
12	1238	111·7	1608	638
13	1308	127·2	1721	627
14	1376	143·4	1833	617
15	1441	160·3	1943	608
16	1504	177·9	2052	599
17	1566	196·2	2161	591
18	1626	215·1	2268	584
19	1685	234·8	2375	577
20	1743	255·2	2481	571
21	1799	276·2	2587	565
22	1854	298·0	2693	560
23	1909	320·5	2798	555
24	1962	343·7	2903	551
25	2015	367·7	3009	547
26	2067	392·5	3114	544
27	2118	418·0	3220	540
28	2169	444·4	3326	537
29	2219	471·6	3432	534
30	2268	499·6	3539	532

XVI. (*continued*).

$\gamma = 4{\cdot}8$

ϕ	(x)	(y)	(t)	(v)
31°	2317	528·6	3647	530
32	2366	558·4	3755	528
33	2414	589·3	3864	526
34	2463	621·1	3974	524
35	2510	654·0	4085	523
36	2558	687·9	4196	522
37	2605	723·0	4310	521
38	2653	759·3	4424	520
39	2700	796·8	4540	519
40	2747	835·5	4657	519
41	2794	875·7	4776	519
42	2841	917·2	4897	519
43	2888	960·2	5020	519
44	2935	1005	5145	519
45	2982	1051	5272	519

$\gamma = 5{\cdot}0$

ϕ	(x)	(y)	(t)	(v)
3°	804	24·6	643	1676
2	438	8·3	390	1282
1	193	1·7	183	1107
0	0	0	0	1000

$\gamma = 5{\cdot}2$

ϕ	(x)	(y)	(t)	(v)
3·5°	1239	49·1	839	2824
3·0	833	25·8	652	1768
2·5	609	15·0	513	1466
2·0	444	8·4	393	1301
1·0	193	1·8	184	1112
0	0	0	0	1000
1	161	1·4	168	923
2	300	5·0	323	866
3	424	10·4	471	820
4	536	17·2	611	784
5	639	25·3	745	753

$\gamma = 5{\cdot}2$

ϕ	(x)	(y)	(t)	(v)
6°	734	34·5	875	727
7	824	44·7	1001	705
8	908	55·7	1123	685
9	988	67·7	1242	667
10	1064	80·4	1359	652
11	1136	93·8	1473	638
12	1206	108·0	1586	626
13	1273	122·8	1697	614
14	1338	138·4	1806	604
15	1400	154·6	1914	595
16	1461	171·4	2021	586
17	1520	188·9	2127	578
18	1578	207·1	2232	571
19	1634	225·9	2336	564
20	1689	245·4	2440	558
21	1743	265·5	2544	553
22	1796	286·3	2647	548
23	1847	307·8	2750	543
24	1898	329·9	2853	538
25	1949	352·8	2956	534
26	1998	376·4	3059	531
27	2047	400·8	3162	528
28	2095	425·9	3265	524
29	2143	451·8	3369	522
30	2190	478·6	3473	519
31	2237	506·1	3578	517
32	2284	534·6	3684	515
33	2330	564·0	3790	513
34	2375	594·3	3897	512
35	2421	625·6	4006	510
36	2466	657·9	4115	509
37	2511	691·3	4225	508
38	2556	725·8	4337	507
39	2601	761·4	4450	507
40	2646	798·3	4564	506
41	2691	836·5	4681	506
42	2735	876·0	4798	506
43	2780	916·8	4918	506
44	2825	959·2	5040	506
45	2869	1003	5164	506

XVI. *(continued).*

$\gamma = 5·4$

ϕ	(X)	(Y)	(T)	(V)
3·0°	866	27·2	664	1884
2·5	623	15·4	518	1508
2·0	450	8·6	395	1322
1·0	194	1·8	184	1117
0	0	0	0	1000

$\gamma = 5·6$

ϕ	(X)	(Y)	(T)	(V)
3·0°	907	29·0	677	2037
2·5	637	15·9	523	1556
2·0	456	8·7	398	1344
1·0	195	1·8	184	1123
0	0	0	0	1000
1	160	1·4	167	918
2	297	4·9	322	858
3	418	10·2	467	811
4	528	16·9	606	774
5	628	24·7	738	742
6	721	33·7	866	716
7	807	43·5	990	693
8	889	54·2	1110	673
9	966	65·7	1227	656
10	1039	78·0	1342	640
11	1109	90·9	1454	626
12	1176	104·6	1565	614
13	1240	118·9	1673	602
14	1303	133·8	1781	592
15	1363	149·4	1886	583
16	1421	165·5	1991	574
17	1478	182·3	2095	566
18	1533	199·8	2198	559
19	1587	217·8	2300	553
20	1640	236·5	2402	547
21	1691	255·7	2503	541
22	1742	275·7	2604	536
23	1792	296·2	2705	531
24	1840	317·5	2806	527
25	1888	339·4	2906	523
26°	1936	362·0	3007	519
27	1982	385·3	3108	516
28	2029	409·3	3209	513
29	2074	434·1	3311	510
30	2119	459·6	3413	508
31	2164	486·0	3515	505
32	2209	513·2	3619	503
33	2253	541·2	3722	502
34	2296	570·2	3827	500
35	2340	600·1	3933	499
36	2383	630·9	4040	497
37	2426	662·8	4148	496
38	2469	695·8	4257	496
39	2512	729·8	4367	495
40	2555	765·0	4479	494
41	2597	801·4	4592	494
42	2640	839·1	4708	494
43	2682	878·1	4825	494
44	2725	918·6	4943	494
45	2768	960·5	5064	494

$\gamma = 5·8$

ϕ	(X)	(Y)	(T)	(V)
3·0°	958	31·3	692	2258
2·5	653	16·4	529	1611
2·0	462	8·9	400	1367
1·0	196	1·8	185	1128
0	0	0	0	1000

$\gamma = 6·0$

ϕ	(X)	(Y)	(T)	(V)
3·0°	1029	34·5	711	2621
2·5	670	17·0	535	1675
2·0	469	9·1	403	1392
1·0	197	1·8	185	1134
0	0	0	0	1000

XVI. (*continued*).

$\gamma = 6{\cdot}0$

ϕ	(x)	(y)	(T)	(v)
1°	159	1·3	167	913
2	294	4·9	320	850
3	413	10·0	464	802
4	520	16·6	601	764
5	618	24·2	732	732
6	708	32·9	858	705
7	792	42·4	980	682
8	870	52·8	1098	662
9	945	63·9	1213	645
10	1016	75·8	1326	629
11	1083	88·3	1437	615
12	1148	101·4	1545	603
13	1210	115·2	1652	591
14	1270	129·6	1757	581
15	1328	144·6	1861	572
16	1384	160·2	1963	563
17	1439	176·3	2065	555
18	1492	193·1	2166	548
19	1544	210·4	2267	542
20	1594	228·4	2366	536
21	1644	246·9	2466	530
22	1692	266·0	2565	525
23	1740	285·8	2663	520
24	1787	306·1	2762	516
25	1833	327·2	2860	512
26	1879	348·8	2959	509
27	1923	371·2	3058	505
28	1968	394·2	3157	502
29	2011	418·0	3257	499
30	2055	442·5	3357	497
31	2098	467·8	3457	495
32	2140	493·8	3558	493
33	2182	520·7	3660	491
34	2224	548·5	3762	489
35	2266	577·1	3866	488
36	2307	606·7	3970	487
37	2349	637·2	4076	486
38	2390	668·7	4183	485
39	2431	701·3	4291	484
40	2472	735·0	4400	484
41	2512	769·9	4511	484
42	2553	806·0	4624	483
43	2594	843·3	4738	483
44	2635	882·0	4854	483
45	2676	922·1	4973	484

$\gamma = 6{\cdot}2$

ϕ	(x)	(y)	(T)	(v)
2·5°	689	17·7	542	1749
2·0	476	9·3	406	1420
1·0	198	1·8	186	1140
0	0	0	0	1000

$\gamma = 6{\cdot}4$

ϕ	(x)	(y)	(T)	(v)
2·5°	712	18·5	550	1839
2·0	483	9·5	409	1449
1·0	199	1·8	186	1146
0	0	0	0	1000
1	158	1·3	166	908
2	292	4·8	319	843
3	408	9·9	462	794
4	513	16·3	597	755
5	608	23·7	726	722
6	695	32·1	850	695
7	777	41·4	970	672
8	853	51·5	1087	652
9	925	62·3	1200	634
10	994	73·7	1311	619
11	1059	85·8	1420	605
12	1122	98·5	1526	592
13	1182	111·8	1631	581
14	1240	125·7	1734	571
15	1296	140·2	1836	562
16	1350	155·2	1937	553
17	1402	170·8	2037	545
18	1454	186·9	2136	538
19	1504	203·7	2235	532
20	1552	220·9	2333	526
21	1600	238·8	2430	520
22	1647	257·2	2527	515
23	1693	276·2	2624	511
24	1738	295·8	2721	506
25	1782	316·0	2818	502
26	1826	336·9	2914	499
27	1869	358·4	3011	495
28	1912	380·5	3108	492
29	1954	403·4	3206	490
30	1995	426·9	3304	487

XVI. (*continued*).

$\gamma = 6{\cdot}4$

φ	(X)	(Y)	(T)	(V)
31°	2036	451·2	3402	485
32	2077	476·2	3501	483
33	2118	502·1	3601	481
34	2158	528·7	3702	480
35	2198	556·2	3803	478
36	2238	584·6	3905	477
37	2278	613·9	4009	476
38	2317	644·2	4114	475
39	2356	675·5	4219	475
40	2396	707·9	4327	474
41	2435	741·3	4435	474
42	2474	776·0	4546	473
43	2513	811·8	4658	473
44	2552	848·9	4772	474
45	2591	887·4	4888	474

$\gamma = 6{\cdot}6$

φ	(X)	(Y)	(T)	(V)
2·5°	737	19·4	55·8	1951
2·0	491	9·7	41·2	1481
1·0	200	1·8	18·7	1152
0	0	0	0	1000

$\gamma = 6{\cdot}8$

φ	(X)	(Y)	(T)	(V)
2·5°	768	20·6	567	2097
2·0	500	9·9	415	1516
1·0	201	1·8	187	1158
0	0	0	0	1000
1	157	1·3	166	904
2	289	4·7	317	836
3	403	9·7	459	786
4	505	16·0	592	746
5	598	23·2	720	713

$\gamma = 6{\cdot}8$

φ	(X)	(Y)	(T)	(V)
6°	684	31·5	843	686
7	763	40·5	961	663
8	837	50·2	1076	642
9	907	60·7	1188	625
10	973	71·8	1297	609
11	1037	83·5	1404	595
12	1097	95·8	1508	583
13	1155	108·7	1612	572
14	1211	122·1	1713	561
15	1265	136·1	1814	552
16	1318	150·6	1913	544
17	1368	165·7	2011	536
18	1418	181·3	2108	529
19	1466	197·4	2205	522
20	1513	214·1	2301	516
21	1559	231·3	2397	511
22	1604	249·0	2492	506
23	1649	267·4	2587	501
24	1692	286·3	2682	497
25	1735	305·8	2777	493
26	1777	325·9	2872	490
27	1819	346·6	2968	486
28	1860	367·9	3063	483
29	1900	389·9	3159	481
30	1940	412·6	3255	478
31	1980	436·0	3351	476
32	2019	460·1	3449	474
33	2058	485·0	3546	472
34	2097	510·7	3645	471
35	2136	537·1	3745	469
36	2174	564·5	3845	468
37	2212	592·7	3947	467
38	2250	621·8	4049	466
39	2288	652·0	4153	465
40	2326	683·1	4258	465
41	2363	715·3	4365	465
42	2401	748·6	4473	464
43	2439	783·1	4583	464
44	2476	818·8	4695	464
45	2514	855·8	4809	465

XVI. (*continued*).

$\gamma = 7{\cdot}0$

ϕ	(X)	(Y)	(T)	(V)
2·5°	806	22·0	578	2299
2·0	509	10·2	418	1555
1·0	202	1·9	188	1165
0	0	0	0	1000

$\gamma = 7{\cdot}2$

ϕ	(X)	(Y)	(T)	(V)
2·5°	856	23·9	592	2611
2·0	519	10·4	422	1598
1·0	203	1·9	188	1171
0	0	0	0	1000
1	156	1·3	165	899
2	286	4·7	316	830
3	399	9·6	456	778
4	499	15·7	588	737
5	589	22·8	714	704
6	672	30·8	835	677
7	750	39·6	952	653
8	822	49·1	1065	633
9	890	59·2	1176	616
10	954	70·0	1283	600
11	1016	81·4	1388	586
12	1074	93·3	1492	574
13	1131	105·8	1593	563
14	1185	118·8	1693	552
15	1237	132·3	1792	543
16	1288	146·4	1889	535
17	1337	161·0	1986	527
18	1385	176·0	2082	520
19	1431	191·6	2177	514
20	1477	207·7	2272	508
21	1521	224·4	2366	502
22	1565	241·6	2459	497
23	1608	259·3	2553	493
24	1650	277·5	2646	489
25	1691	296·4	2740	485
26	1732	315·8	2833	481
27	1772	335·8	2926	478
28	1811	356·4	3020	475
29	1851	377·6	3114	472
30	1889	399·5	3209	470
31°	1928	422·1	3304	468
32	1966	445·4	3399	466
33	2003	469·4	3495	464
34	2041	494·1	3592	462
35	2078	519·7	3690	461
36	2115	546·0	3788	460
37	2152	573·2	3888	459
38	2188	601·4	3989	458
39	2225	630·4	4091	457
40	2261	660·4	4194	457
41	2298	691·5	4299	456
42	2334	723·6	4405	456
43	2370	756·8	4513	456
44	2406	791·3	4623	456
45	2443	826·9	4735	456

$\gamma = 7{\cdot}4$

ϕ	(X)	(Y)	(T)	(V)
2·5°	931	26·9	610	3217
2·0	530	10·7	426	1647
1·0	204	1·9	188	1178
0	0	0	0	1000

$\gamma = 7{\cdot}6$

ϕ	(X)	(Y)	(T)	(V)
2·0°	542	11·1	430	1701
1·0	205	1·9	189	1185
0	0	0	0	1000
1	156	1·3	165	895
2	284	4·6	314	823
3	394	9·4	453	770
4	492	15·4	584	729
5	581	22·4	709	696
6	662	30·2	828	668
7	737	38·7	944	645
8	807	48·0	1056	625
9	873	57·9	1164	607
10	936	68·3	1270	591

XVI. (*continued*).

$\gamma = 7·6$

φ	(X)	(Y)	(T)	(V)
11°	996	79·4	1374	578
12	1053	91·0	1476	565
13	1107	103·1	1576	554
14	1160	115·7	1674	544
15	1211	128·8	1771	535
16	1260	142·4	1867	526
17	1307	156·6	1963	519
18	1354	171·2	2057	512
19	1399	186·3	2151	506
20	1443	201·9	2244	500
21	1486	218·0	2336	494
22	1528	234·6	2428	489
23	1570	251·7	2520	485
24	1610	269·4	2612	481
25	1650	287·6	2704	477
26	1690	306·4	2796	473
27	1728	325·7	2888	470
28	1767	345·7	2980	467
29	1805	366·2	3072	464
30	1842	387·4	3165	462
31	1879	409·2	3259	460
32	1916	431·7	3353	458
33	1952	454·9	3447	456
34	1988	478·9	3542	454
35	2024	503·5	3638	453
36	2060	529·0	3735	452
37	2096	555·3	3833	451
38	2131	582·5	3932	450
39	2166	610·5	4033	449
40	2201	639·5	4134	449
41	2236	669·5	4237	448
42	2272	700·6	4342	448
43	2307	732·7	4448	448
44	2342	765·9	4555	448
45	2377	800·4	4665	448

$\gamma = 7·8$

φ	(X)	(Y)	(T)	(V)
2°·0	555	11·4	435	1764
1·0	206	1·9	189	1192
0	0	0	0	1000

$\gamma = 8·0$

φ	(X)	(Y)	(T)	(V)
2°·0	569	11·8	439	1837
1·0	207	1·9	190	1199
0	0	0	0	1000
1	155	1·3	164	889
2	281	4·6	313	817
3	390	9·3	451	763
4	486	15·2	580	722
5	572	22·0	704	688
6	652	29·6	822	660
7	725	37·9	936	637
8	794	46·9	1046	617
9	858	56·6	1153	599
10	919	66·8	1258	583
11	977	77·5	1360	570
12	1032	88·8	1460	557
13	1085	100·5	1559	546
14	1136	112·8	1656	536
15	1186	125·5	1752	527
16	1233	138·7	1846	519
17	1280	152·4	1940	511
18	1325	166·6	2033	504
19	1368	181·3	2125	498
20	1411	196·4	2217	492
21	1453	212·0	2308	487
22	1494	228·1	2399	482
23	1534	244·8	2489	477
24	1573	261·9	2580	473
25	1612	279·5	2670	469
26	1650	297·7	2761	466
27	1688	316·5	2851	463
28	1725	335·8	2942	460
29	1762	355·7	3033	457
30	1798	376·2	3124	455
31	1834	397·3	3216	452
32	1869	419·1	3308	450
33	1905	441·6	3402	449
34	1940	464·7	3495	447
35	1974	488·6	3590	446
36	2009	513·3	3685	445
37	2043	538·8	3782	444
38	2077	565·0	3879	443
39	2112	592·2	3978	442
40	2146	620·3	4078	441
41	2180	649·3	4179	441
42	2214	679·3	4282	441
43	2247	710·4	4386	441
44	2281	742·5	4492	441
45	2315	775·9	4600	441

XVII.

Values of $\{1000 \div v\}^3$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f.s.											–
40	15·63	15·51	15·39	15·28	15·17	15·05	14·94	14·83	14·72	14·62	11
41	14·51	14·40	14·30	14·20	14·09	13·99	13·89	13·79	13·69	13·59	10
42	13·50	13·40	13·31	13·21	13·12	13·03	12·94	12·85	12·76	12·67	9
43	1 2·578	2·491	2·404	2·318	2·233	2·149	2·065	1·983	1·901	1·820	84
44	1·739	1·660	1·581	1·503	1·425	1·348	1·272	1·197	1·122	1·048	77
45	0·974	0·901	0·829	0·757	0·686	0·616	0·547	0·478	0·409	0·341	70
46	1 0·274	0·207	0·141	0·075	0·010	*9·946	*9·882	*9·819	*9·756	*9·694	64
47	0 9·632	9·571	9·510	9·450	9·390	9·331	9·272	9·214	9·156	9·099	59
48	9·042	8·986	8·930	8·875	8·820	8·766	8·711	8·658	8·605	8·552	54
49	8·500	8·448	8·397	8·346	8·295	8·245	8·195	8·146	8·097	8·048	50
50	8·000	7·952	7·905	7·858	7·811	7·765	7·719	7·673	7·628	7·583	46
51	7·539	7·494	7·451	7·407	7·364	7·321	7·279	7·237	7·195	7·153	43
52	7·112	7·071	7·031	6·990	6·950	6·911	6·871	6·832	6·794	6·755	40
53	6·717	6·679	6·642	6·604	6·567	6·530	6·494	6·458	6·422	6·386	37
54	6·351	6·316	6·281	6·246	6·212	6·178	6·144	6·110	6·077	6·043	34
55	6·011	5·978	5·945	5·913	5·881	5·850	5·818	5·787	5·756	5·725	32
56	5·694	5·664	5·634	5·604	5·574	5·544	5·515	5·486	5·457	5·428	30
57	5·400	5·372	5·343	5·315	5·288	5·260	5·233	5·206	5·179	5·152	28
58	5·125	5·099	5·073	5·047	5·021	4·995	4·969	4·944	4·919	4·894	26
59	4·869	4·844	4·820	4·796	4·771	4·747	4·724	4·700	4·676	4·653	24
60	4·630	4·607	4·584	4·561	4·538	4·516	4·494	4·471	4·449	4·427	23
61	4·406	4·384	4·363	4·341	4·320	4·299	4·278	4·257	4·237	4·216	21
62	4·196	4·176	4·156	4·136	4·116	4·096	4·076	4·057	4·038	4·018	20
63	3·999	3·980	3·961	3·943	3·924	3·906	3·887	3·869	3·851	3·833	19
64	3·815	3·797	3·779	3·762	3·744	3·727	3·709	3·692	3·675	3·658	17
65	3·641	3·625	3·608	3·591	3·575	3·559	3·542	3·526	3·510	3·494	16
66	3·478	3·463	3·447	3·431	3·416	3·400	3·385	3·370	3·355	3·340	15
67	3·325	3·310	3·295	3·281	3·266	3·252	3·237	3·223	3·209	3·194	15
68	3·180	3·166	3·152	3·139	3·125	3·111	3·098	3·084	3·071	3·057	14
69	3·044	3·031	3·018	3·005	2·992	2·979	2·966	2·953	2·941	2·928	13
70	2·915	2·903	2·891	2·878	2·866	2·854	2·842	2·830	2·818	2·806	12
71	2·794	2·782	2·770	2·759	2·747	2·736	2·724	2·713	2·702	2·690	12
72	2·679	2·668	2·657	2·646	2·635	2·624	2·613	2·603	2·592	2·581	11
73	2·571	2·560	2·550	2·539	2·529	2·518	2·508	2·498	2·488	2·478	10
74	2·468	2·458	2·448	2·438	2·428	2·418	2·409	2·399	2·389	2·379	10
75	2·370	2·361	2·352	2·342	2·333	2·324	2·314	2·305	2·296	2·287	9

XVII. (*continued*).

$$\{1000 \div v\}^3.$$

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
76	2·2780	2691	2601	2513	2424	2337	2249	2162	2076	1990	88
77	1904	1819	1734	1650	1566	1483	1400	1318	1235	1154	83
78	1073	0992	0911	0831	0752	0672	0594	0515	0437	0360	79
79	0282	0206	0129	0053	*9977	*9902	*9827	*9753	*9679	*9605	75
80	1·9531	9458	9386	9313	9241	9170	9098	9027	8957	8887	72
81	1·8817	8747	8678	8609	8541	8473	8405	8337	8270	8203	68
82	8137	8071	8005	7939	7874	7809	7744	7680	7616	7552	65
83	7489	7426	7363	7301	7239	7177	7115	7054	6993	6932	62
84	6872	6812	6752	6692	6633	6574	6515	6457	6399	6341	59
85	6283	6226	6169	6112	6056	5999	5943	5888	5832	5777	56
86	1·5722	5667	5613	5559	5505	5451	5397	5344	5291	5239	54
87	5186	5134	5082	5030	4978	4927	4876	4825	4775	4724	51
88	4674	4624	4575	4525	4476	4427	4378	4329	4281	4233	49
89	4185	4137	4090	4043	3996	3949	3902	3856	3809	3763	47
90	3717	3672	3626	3581	3536	3491	3447	3402	3358	3314	45
91	1·3270	3227	3183	3140	3097	3054	3011	2969	2926	2884	43
92	2842	2800	2759	2717	2676	2635	2594	2553	2513	2473	41
93	2432	2392	2352	2313	2273	2234	2195	2156	2117	2078	39
94	2040	2001	1963	1925	1887	1850	1812	1775	1738	1700	38
95	1664	1627	1590	1554	1517	1481	1445	1410	1374	1338	36
96	1·1303	1268	1233	1198	1163	1128	1094	1059	1025	0991	35
97	0957	0923	0889	0856	0822	0789	0756	0723	0690	0657	33
98	0625	0592	0560	0528	0496	0464	0432	0400	0369	0337	32
99	0306	0275	0244	0213	0182	0152	0121	0091	0060	0030	31
100	0000	*9970	*9940	*9911	*9881	*9852	*9822	*9793	*9764	*9735	30
101	0·9706	9677	9649	9620	9592	9563	9535	9507	9479	9451	28
102	9423	9396	9368	9341	9313	9286	9259	9232	9205	9178	27
103	9151	9125	9098	9072	9046	9019	8993	8967	8941	8916	26
104	8890	8864	8839	8814	8788	8763	8738	8713	8688	8663	25
105	8638	8614	8589	8565	8540	8516	8492	8468	8444	8420	24
106	0·8396	8373	8349	8325	8302	8279	8255	8232	8209	8186	23
107	8163	8140	8117	8095	8072	8050	8027	8005	7983	7960	23
108	7938	7916	7894	7873	7851	7829	7808	7786	7765	7743	22
109	7722	7701	7680	7658	7637	7617	7596	7575	7554	7534	21
110	7513	7493	7472	7452	7432	7412	7392	7372	7352	7332	20
111	0·7312	7292	7273	7253	7233	7214	7195	7175	7156	7137	19
112	7118	7099	7080	7061	7042	7023	7005	6986	6967	6949	19
113	6931	6912	6894	6876	6857	6839	6821	6803	6785	6768	18
114	6750	6732	6714	6697	6679	6662	6644	6627	6610	6592	17
115	6575	6558	6541	6524	6507	6490	6473	6457	6440	6423	17

XVII. (*continued*).

$$\{1000 \div v\}^3.$$

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
116	0·6407	6390	6374	6357	6341	6324	6308	6292	6276	6260	16
117	6244	6228	6212	6196	6180	6164	6149	6133	6117	6102	16
118	6086	6071	6056	6040	6025	6010	5994	5979	5964	5949	15
119	5934	5919	5904	5890	5875	5860	5845	5831	5816	5802	15
120	5787	5773	5758	5744	5730	5715	5701	5687	5673	5659	14
121	0·5645	5631	5617	5603	5589	5575	5562	5548	5534	5521	14
122	5507	5494	5480	5467	5453	5440	5427	5413	5400	5387	13
123	5374	5361	5348	5335	5322	5309	5296	5283	5270	5258	13
124	5245	5232	5220	5207	5194	5182	5170	5157	5145	5132	13
125	5120	5108	5096	5083	5071	5059	5047	5035	5023	5011	12
126	0·4999	4987	4975	4964	4952	4940	4928	4917	4905	4893	12
127	4882	4870	4859	4848	4836	4825	4813	4802	4791	4780	11
128	4768	4757	4746	4735	4724	4713	4702	4691	4680	4669	11
129	4658	4648	4637	4626	4615	4605	4594	4583	4573	4562	11
130	4552	4541	4531	4520	4510	4500	4489	4479	4469	4458	10
131	0·4448	4438	4428	4418	4408	4398	4388	4378	4368	4358	10
132	4348	4338	4328	4318	4309	4299	4289	4279	4270	4260	10
133	4251	4241	4231	4222	4212	4203	4194	4184	4175	4165	9
134	4156	4147	4138	4128	4119	4110	4101	4092	4083	4074	9
135	4064	4055	4046	4037	4029	4020	4011	4002	3993	3984	9
136	0·3975	3967	3958	3949	3941	3932	3923	3915	3906	3898	9
137	3889	3881	3872	3864	3855	3847	3838	3830	3822	3813	8
138	3805	3797	3789	3780	3772	3764	3756	3748	3740	3732	8
139	3724	3716	3708	3700	3692	3684	3676	3668	3660	3652	8
140	3644	3637	3629	3621	3613	3606	3598	3590	3583	3575	8
141	0·3567	3560	3552	3545	3537	3530	3522	3515	3507	3500	8
142	3493	3485	3478	3470	3463	3456	3449	3441	3434	3427	7
143	3420	3413	3405	3398	3391	3384	3377	3370	3363	3356	7
144	3349	3342	3335	3328	3321	3314	3308	3301	3294	3287	7
145	3280	3273	3267	3260	3253	3247	3240	3233	3227	3220	7
146	0·32132	2066	2001	1935	1870	1804	1739	1674	1610	1545	65
147	1481	1417	1353	1289	1225	1162	1099	1036	0973	0910	63
148	0847	0785	0722	0660	0598	0537	0475	0414	0352	0291	62
149	0230	0169	0109	0048	*9988	*9928	*9868	*9808	*9748	*9689	60
150	0·29630	9570	9511	9452	9394	9335	9277	9219	9161	9103	59
151	0·29045	8987	8930	8872	8815	8758	8701	8645	8588	8532	57
152	8475	8419	8363	8307	8252	8196	8141	8086	8030	7975	56
153	7921	7866	7811	7757	7703	7649	7595	7541	7487	7434	54
154	7380	7327	7274	7221	7168	7115	7063	7010	6958	6906	53
155	6854	6802	6750	6698	6647	6596	6544	6493	6442	6391	51

XVIII.

$$W_\phi = \tan\phi\left(\sec^5\phi + \frac{5}{4}\sec^3\phi + \frac{15}{8}\sec\phi\right) + \frac{15}{8}\log_e\tan\left(\frac{\pi}{4}+\frac{\phi}{2}\right).$$

ϕ	W_ϕ	Log W_ϕ	Log ΔW_ϕ	ϕ	W_ϕ	Log W_ϕ	Log ΔW_ϕ
			9·02020				
1°	0·10476	9·02020	9·02111	41°	9·7112	0·98727	9·89910
2	0·20974	9·32168	9·02296	42	10·504	1·02135	9·94691
3	0·31517	9·49855	9·02572	43	11·389	1·05648	9·99641
4	0·42127	9·62456	9·02947	44	12·381	1·09274	0·04767
5	0·52829	9·72287	9·03411	45	13·497	1·13023	0·10075
6	0·63646	9·80377	9·03969	46	14·758	1·16902	0·15573
7	0·74603	9·87276	9·04618	47	16·189	1·20922	0·21265
8	0·85725	9·93311	9·05366	48	17·821	1·25093	0·27160
9	0·97040	9·98695	9·06206	49	19·690	1·29424	0·33268
10	1·0858	0·03573	9·07140	50	21·841	1·33927	0·39595
11	1·2036	0·08049	9·08174	51	24·330	1·38612	0·46151
12	1·3243	0·12200	9·09300	52	27·224	1·43495	0·52946
13	1·4482	0·16083	9·10527	53	30·608	1·48583	0·59992
14	1·5757	0·19746	9·11850	54	34·588	1·53893	0·67300
15	1·7070	0·23224	9·13271	55	39·298	1·59437	0·74882
16	1·8428	0·26547	9·14795	56	44·906	1·65230	0·82755
17	1·9834	0·29740	9·16415	57	51·629	1·71289	0·90931
18	2·1293	0·32823	9·18142	58	59·744	1·77630	0·99430
19	2·2811	0·35815	9·19967	59	69·614	1·84270	1·08268
20	2·4395	0·38730	9·21901	60	81·711	1·91228	1·17464
21	2·6051	0·41582	9·23938	61	96·661	1·98525	1·27049
22	2·7786	0·44383	9·26081	62	115·30	2·06184	1·37035
23	2·9609	0·47143	9·28332	63	138·76	2·14228	1·47462
24	3·1529	0·49871	9·30698	64	168·59	2·22684	1·58353
25	3·3557	0·52578	9·33171	65	206·92	2·31580	1·69747
26	3·5703	0·55271	9·35761	66	256·75	2·40951	1·81681
27	3·7982	0·57957	9·38466	67	322·33	2·50831	1·94199
28	4·0406	0·60645	9·41286	68	409·83	2·61260	2·07352
29	4·2994	0·63341	9·44229	69	528·28	2·72286	2·21204
30	4·5763	0·66051	9·47293	70	691·22	2·83962	2·35804
31	4·8734	0·68783	9·50481	71	919·27	2·96344	2·51250
32	5·1931	0·71543	9·53800	72	1244·7	3·09508	2·67617
33	5·5383	0·74337	9·57245	73	1719·2	3·23532	2·85019
34	5·9119	0·77173	9·60826	74	2427·4	3·38514	3·03579
35	6·3177	0·80056	9·64542	75	3513·3	3·54572	3·23448
36	6·7597	0·82992	9·68399	76	5229·2	3·71843	3·44813
37	7·2427	0·85990	9·72399	77	8035·4	3·90501	3·67899
38	7·7723	0·89055	9·76545	78	12811	4·10757	3·92994
39	8·3550	0·92195	9·80843	79	21321	4·32880	4·20462
40	8·9984	0·95416	9·85297	80	37339	4·57217	

XIX.

$\{1000 \div v\}^6$.

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											—
50	64·00	63·24	62·49	61·74	61·01	60·30	59·58	58·88	58·19	57·50	72
51	56·83	56·17	55·51	54·87	54·23	53·60	52·98	52·37	51·76	51·17	63
52	50·57	50·00	49·42	48·86	48·31	47·76	47·22	46·68	46·15	45·63	55
53	45·12	44·61	44·11	43·62	43·13	42·65	42·17	41·70	41·24	40·78	48
54	40·33	39·89	39·45	39·01	38·58	38·16	37·74	37·33	36·93	36·52	42
55	36·13	35·74	35·35	34·97	34·59	34·22	33·85	33·49	33·13	32·77	37
56	32·42	32·08	31·74	31·40	31·07	30·74	30·42	30·10	29·78	29·47	33
57	29·16	28·85	28·55	28·25	27·96	27·67	27·38	27·10	26·82	26·54	29
58	26·27	26·00	25·73	25·47	25·21	24·95	24·70	24·44	24·20	23·95	26
59	23·71	23·47	23·23	23·00	22·77	22·54	22·31	22·09	21·87	21·65	23
60	21·43	21·22	21·01	20·80	20·60	20·39	20·19	19·99	19·80	19·60	20
61	19·41	19·22	19·03	18·85	18·66	18·48	18·30	18·13	17·95	17·78	18
62	17·61	17·44	17·27	17·10	16·94	16·78	16·62	16·46	16·30	16·15	16
63	16·00	15·84	15·69	15·54	15·40	15·25	15·11	14·97	14·83	14·69	15
64	14·55	14·42	14·28	14·15	14·02	13·89	13·76	13·63	13·51	13·38	13
65	13·26	13·14	13·02	12·90	12·78	12·66	12·55	12·43	12·32	12·21	12
66	12·10	11·99	11·88	11·77	11·67	11·56	11·46	11·36	11·25	11·15	11
67	11·05	10·96	10·86	10·76	10·67	10·57	10·48	10·39	10·30	10·20	9
68	10·114	10·025	9·938	9·851	9·765	9·679	9·595	9·512	9·429	9·347	85
69	9·266	9·186	9·106	9·027	8·950	8·874	8·797	8·722	8·646	8·572	77
70	8·500	8·427	8·355	8·284	8·214	8·144	8·076	8·007	7·940	7·873	70
71	7·806	7·741	7·676	7·611	7·548	7·485	7·422	7·360	7·299	7·238	63
72	7·178	7·119	7·060	7·001	6·943	6·886	6·829	6·773	6·718	6·662	57
73	6·608	6·554	6·500	6·447	6·395	6·343	6·291	6·240	6·190	6·140	52
74	6·090	6·041	5·992	5·944	5·896	5·849	5·802	5·755	5·709	5·664	47
75	5·619	5·574	5·530	5·486	5·442	5·399	5·356	5·314	5·272	5·230	43
76	5·189	5·149	5·108	5·068	5·028	4·989	4·950	4·912	4·873	4·836	39
77	4·798	4·761	4·724	4·687	4·651	4·615	4·580	4·544	4·509	4·475	36
78	4·440	4·407	4·373	4·339	4·306	4·273	4·241	4·209	4·177	4·145	33
79	4·114	4·083	4·052	4·021	3·991	3·961	3·931	3·902	3·872	3·843	30
80	3·815	3·786	3·758	3·730	3·702	3·675	3·647	3·620	3·594	3·567	28
81	3·541	3·515	3·489	3·463	3·438	3·412	3·387	3·362	3·338	3·314	25
82	3·289	3·265	3·242	3·218	3·195	3·172	3·149	3·126	3·103	3·081	23
83	3·059	3·037	3·015	2·993	2·972	2·950	2·929	2·908	2·888	2·867	21
84	2·847	2·826	2·806	2·786	2·767	2·747	2·728	2·708	2·689	2·670	20
85	2·651	2·633	2·614	2·596	2·578	2·560	2·542	2·524	2·507	2·489	18

XIX. (*continued*).

$$\{1000 \div v\}^6.$$

v	0	1	2	3	4	5	6	7	8	9	Δ
f. s.											–
86	2·472	2·455	2·438	2·421	2·404	2·387	2·371	2·354	2·338	2·322	17
87	2·306	2·290	2·275	2·259	2·244	2·228	2·213	2·198	2·183	2·168	15
88	2·153	2·139	2·124	2·110	2·095	2·081	2·067	2·053	2·039	2·026	14
89	2·012	1·999	1·985	1·972	1·959	1·946	1·933	1·920	1·907	1·894	13
90	1·882	1·869	1·857	1·844	1·832	1·820	1·808	1·796	1·784	1·773	12
91	1·761	1·749	1·738	1·727	1·715	1·704	1·693	1·682	1·671	1·660	11
92	1·649	1·638	1·628	1·617	1·607	1·596	1·586	1·576	1·566	1·556	10
93	1·546	1·536	1·526	1·516	1·506	1·497	1·487	1·478	1·468	1·459	10
94	1·450	1·440	1·431	1·422	1·413	1·404	1·395	1·386	1·378	1·369	9
95	1·3604	3518	3433	3349	3265	3182	3099	3017	2936	2855	83
96	2775	2696	2617	2539	2461	2384	2307	2231	2155	2080	77
97	2005	1931	1858	1785	1713	1641	1569	1498	1428	1358	72
98	1·1289	1220	1151	1084	1016	0949	0883	0817	0751	0686	67
99	0622	0557	0494	0431	0368	0305	0243	0182	0121	0060	62
100	0000	*9940	*9881	*9822	*9764	*9705	*9647	*9590	*9533	*9477	58
101	0·9420	9365	9309	9254	9200	9146	9092	9038	8985	8932	54
102	8880	8828	8776	8725	8674	8623	8573	8523	8473	8424	51
103	8375	8326	8278	8230	8182	8135	8088	8041	7995	7949	47
104	0·7903	7858	7813	7768	7723	7679	7635	7591	7548	7505	44
105	7462	7420	7378	7336	7294	7252	7211	7171	7130	7090	41
106	7050	7010	6970	6931	6892	6853	6815	6777	6739	6701	39
107	0·6663	6626	6589	6552	6516	6480	6444	6408	6372	6337	36
108	6302	6267	6232	6198	6163	6129	6096	6062	6029	5996	34
109	5963	5930	5897	5865	5833	5801	5769	5738	5707	5676	32
110	0·5645	5614	5584	5553	5523	5493	5463	5434	5405	5375	30
111	5346	5318	5289	5261	5232	5204	5176	5149	5121	5094	28
112	5066	5039	5012	4986	4959	4933	4906	4880	4854	4829	26
113	0·4803	4778	4752	4727	4702	4678	4653	4628	4604	4580	25
114	4556	4532	4508	4485	4461	4438	4415	4392	4369	4346	23
115	4323	4301	4278	4256	4234	4212	4190	4169	4147	4126	22
116	0·4104	4083	4062	4041	4021	4000	3979	3959	3939	3918	21
117	3898	3878	3859	3839	3819	3800	3781	3761	3742	3723	19
118	3704	3686	3667	3648	3630	3612	3593	3575	3557	3539	18
119	3521	3504	3486	3469	3451	3434	3417	3400	3383	3366	17

XX.

Log τ corresponding to temperatures and pressures when the air is ⅔rds saturated with moisture.

Temperature	15 in.	20 in.	22 in.	24 in.	26 in.	27 in.	28 in.	29 in.	30 in.	31 in.
F										
9°	9·7453	8703	9117	9494	9842	*0006	*0164	*0317	*0464	*0606
10	7444	8693	9107	9485	9832	9996	*0154	*0306	*0454	*0596
11	7434	8684	9098	9476	9823	9987	*0145	*0297	*0445	*0587
12	9·7425	8674	9088	9466	9813	9977	*0135	*0288	*0435	*0577
13	7415	8665	9079	9457	9804	9968	*0126	*0278	*0426	*0568
14	7406	8656	9070	9447	9796	9959	*0117	*0269	*0417	*0559
15	9·7397	8646	9061	9438	9786	9950	*0108	*0260	*0408	*0550
16	7388	8637	9051	9429	9777	9941	*0099	*0251	*0398	*0541
17	7379	8628	9042	9420	9768	9931	*0089	*0242	*0389	*0532
18	9·7370	8619	9033	9411	9759	9922	*0080	*0233	*0380	*0522
19	7360	8609	9023	9401	9749	9913	*0071	*0223	*0371	*0513
20	7351	8600	9014	9392	9740	9903	*0062	*0215	*0361	*0503
21	9·7342	8591	9005	9383	9730	9895	*0052	*0205	*0352	*0495
22	7332	8582	8996	9374	9721	9885	*0043	*0195	*0343	*0485
23	7324	8573	8987	9365	9713	9876	*0034	*0187	*0334	*0476
24	9·7314	8564	8978	9356	9703	9867	*0025	*0177	*0325	*0467
25	7305	8555	8968	9346	9694	9858	*0016	*0168	*0315	*0458
26	7296	8545	8959	9337	9684	9848	*0006	*0159	*0306	*0448
27	9·7286	8536	8950	9327	9675	9839	9997	*0149	*0297	*0439
28	7277	8527	8941	9319	9667	9830	9988	*0141	*0288	*0430
29	7268	8517	8932	9309	9657	9821	9979	*0131	*0278	*0421
30	9·7259	8508	8922	9300	9647	9811	9969	*0122	*0269	*0412
31	7250	8499	8913	9291	9639	9803	9961	*0113	*0260	*0403
32	7240	8490	8904	9281	9629	9793	9951	*0103	*0251	*0393
33	9·7232	8481	8895	9273	9620	9785	9942	*0095	*0242	*0384
34	7222	8471	8886	9263	9611	9775	9933	*0085	*0233	*0375
35	7214	8463	8877	9255	9602	9766	9924	*0077	*0224	*0366
36	9·7204	8454	8868	9246	9593	9757	9915	*0068	*0215	*0357
37	7195	8444	8858	9236	9584	9747	9906	*0058	*0205	*0347
38	7186	8435	8850	9227	9575	9739	9897	*0049	*0197	*0339
39	9·7176	8426	8840	9218	9565	9729	9887	*0039	*0187	*0329
40	7168	8418	8832	9210	9557	9721	9879	*0032	*0179	*0321
41	7160	8409	8823	9201	9548	9712	9870	*0023	*0170	*0312
42	9·7150	8399	8813	9191	9539	9703	9861	*0013	*0160	*0302
43	7142	8391	8805	9183	9530	9694	9852	*0005	*0152	*0294
44	7132	8382	8795	9173	9521	9685	9843	9995	*0142	*0284
45	9·7124	8373	8787	9165	9512	9676	9834	9987	*0134	*0276
46	7114	8363	8777	9155	9503	9667	9825	9977	*0124	*0267
47	7105	8354	8768	9146	9494	9658	9815	9968	*0115	*0258
48	9·7097	8346	8760	9138	9486	9650	9807	9960	*0107	*0249
49	7087	8337	8750	9128	9476	9640	9798	9950	*0097	*0240
50	7078	8327	8741	9119	9466	9631	9789	9941	*0088	*0230
51	9·7070	8319	8733	9111	9459	9622	9780	9933	*0080	*0222
52	7061	8311	8724	9103	9450	9614	9772	9925	*0072	*0214
53	7052	8301	8716	9093	9441	9605	9763	9915	*0063	*0205

XX. (*continued*).

Temperature	15 in.	20 in.	22 in.	24 in.	26 in.	27 in.	28 in.	29 in.	30 in.	31 in.
F										
54°	9·7042	8292	8706	9083	9431	9595	9753	9905	*0053	*0195
55	7033	8283	8696	9074	9422	9586	9744	9896	*0043	*0186
56	7024	8273	8687	9065	9413	9577	9735	9887	*0034	*0177
57	9·7015	8264	8678	9056	9404	9567	9725	9878	*0025	*0167
58	7007	8256	8670	9048	9395	9559	9717	9870	*0017	*0159
59	6997	8246	8661	9038	9386	9550	9708	9860	*0007	*0150
60	9·6988	8237	8651	9029	9377	9540	9699	9851	9998	*0141
61	6980	8229	8643	9021	9368	9532	9690	9843	9990	*0132
62	6970	8220	8633	9011	9359	9523	9681	9833	9980	*0123
63	9·6961	8211	8624	9002	9350	9514	9672	9824	9971	*0114
64	6952	8201	8615	8993	9340	9504	9662	9815	9962	*0104
65	6942	8191	8606	8983	9331	9495	9653	9805	9952	*0095
66	9·6934	8183	8597	8975	9323	9487	9644	9797	9944	*0086
67	6925	8174	8588	8965	9313	9477	9635	9787	9935	*0077
68	6916	8165	8579	8957	9304	9468	9627	9779	9926	*0069
69	9·6907	8156	8570	8948	9296	9460	9618	9770	9918	*0060
70	6898	8147	8561	8939	9287	9450	9609	9761	9908	*0051
71	6888	8138	8552	8929	9277	9441	9599	9752	9899	*0041
72	9·6880	8129	8543	8921	9269	9432	9590	9743	9890	*0032
73	6871	8120	8535	8912	9260	9424	9582	9734	9882	*0024
74	6862	8111	8526	8904	9251	9415	9573	9726	9873	*0015
75	9·6853	8102	8516	8894	9242	9406	9564	9716	9863	*0006
76	6843	8093	8506	8885	9232	9396	9554	9706	9853	9996
77	6835	8084	8498	8876	9224	9387	9545	9698	9845	9987
78	9·6825	8075	8488	8866	9214	9378	9536	9688	9835	9978
79	6816	8066	8479	8858	9205	9369	9527	9679	9827	9969
80	6807	8056	8470	8848	9195	9359	9517	9670	9817	9959
81	9·6797	8046	8460	8838	9186	9350	9508	9660	9807	9950
82	6788	8037	8452	8829	9177	9341	9499	9651	9799	9941
83	6779	8029	8443	8821	9168	9332	9490	9643	9790	9932
84	9·6771	8020	8434	8812	9159	9323	9481	9634	9781	9923
85	6761	8011	8424	8802	9150	9314	9471	9624	9771	9914
86	6752	8001	8415	8793	9141	9304	9463	9615	9762	9905
87	9·6743	7993	8406	8784	9132	9296	9454	9606	9753	9896
88	6733	7982	8397	8774	9122	9286	9444	9596	9744	9886
89	6724	7973	8388	8766	9113	9277	9435	9588	9735	9877
90	9·6715	7964	8378	8756	9104	9268	9426	9578	9726	9868
91	6706	7955	8369	8747	9094	9258	9416	9568	9716	9858
92	6695	7945	8359	8737	9084	9248	9406	9559	9706	9848
93	9·6687	7936	8350	8728	9075	9239	9397	9550	9697	9839
94	6677	7926	8340	8718	9066	9229	9387	9540	9687	9829
95	6668	7917	8331	8709	9056	9220	9378	9531	9678	9820
96	9·6658	7907	8321	8699	9047	9210	9368	9521	9668	9810
97	6647	7897	8311	8689	9036	9200	9358	9510	9658	9800
98	6637	7887	8301	8679	9027	9190	9349	9501	9648	9790
99	9·6628	7878	8291	8669	9016	9180	9338	9490	9638	9780
100	9·6619	7868	8281	8659	9007	9171	9329	9482	9629	9771

XXI.

Log τ for various heights, gravity and temperature being supposed constant.

Ht.	000	100	200	300	400	500	600	700	800	900
Feet										
39	9·4646	4630	4615	4599	4583	4568	4552	4537	4521	4505
38	4802	4786	4771	4755	4739	4724	4708	4693	4677	4661
37	4958	4942	4927	4911	4895	4880	4864	4849	4833	4817
36	5114	5098	5083	5067	5051	5036	5020	5005	4989	4973
35	9·5270	5254	5239	5223	5207	5192	5176	5161	5145	5129
34	5426	5410	5394	5379	5363	5348	5332	5316	5301	5285
33	5582	5566	5550	5535	5519	5504	5488	5472	5457	5441
32	9·5738	5722	5706	5691	5675	5660	5644	5628	5613	5597
31	5894	5878	5862	5847	5831	5816	5800	5784	5769	5753
30	6050	6034	6018	6003	5987	5972	5956	5940	5925	5909
29	9·6206	6190	6174	6159	6143	6128	6112	6096	6081	6065
28	6362	6346	6330	6315	6299	6284	6268	6252	6237	6221
27	6518	6502	6486	6471	6455	6440	6424	6408	6393	6377
26	9·6674	6658	6642	6627	6611	6596	6580	6564	6549	6533
25	6830	6814	6798	6783	6767	6752	6736	6720	6705	6689
24	6985	6970	6954	6939	6923	6907	6892	6876	6861	6845
23	9·7141	7126	7110	7095	7079	7063	7048	7032	7016	7001
22	7297	7282	7266	7251	7235	7219	7204	7188	7173	7157
21	7453	7438	7422	7407	7391	7375	7360	7344	7329	7313
20	9·7609	7594	7578	7563	7547	7531	7516	7500	7485	7469
19	7765	7750	7734	7719	7703	7687	7672	7656	7641	7625
18	7921	7906	7890	7875	7859	7843	7828	7812	7797	7781
17	9·8077	8062	8046	8031	8015	7999	7984	7968	7953	7937
16	8233	8218	8202	8187	8171	8155	8140	8124	8109	8093
15	8389	8374	8358	8343	8327	8311	8296	8280	8265	8249
14	9·8545	8530	8514	8498	8483	8467	8452	8436	8420	8405
13	8701	8686	8670	8654	8639	8623	8608	8592	8576	8561
12	8857	8842	8826	8810	8795	8779	8764	8748	8732	8717
11	9·9013	8998	8982	8966	8951	8935	8920	8904	8888	8873
10	9169	9154	9138	9122	9107	9091	9076	9060	9044	9029
9	9325	9310	9294	9278	9263	9247	9232	9216	9200	9185
8	9·9481	9466	9450	9434	9419	9403	9388	9372	9357	9341
7	9637	9622	9606	9590	9575	9559	9544	9528	9512	9497
6	9793	9778	9762	9746	9731	9715	9700	9684	9668	9653
5	9·9949	9934	9918	9902	9887	9871	9856	9840	9824	9809
4	0·0105	0089	0074	0058	0043	0027	0011	*9996	*9980	*9965
3	0261	0245	0230	0214	0199	0183	0167	0152	0136	0121
2	0·0417	0401	0386	0370	0355	0339	0323	0308	0292	0277
1	0573	0557	0542	0526	0511	0495	0479	0464	0448	0433
0	0729	0713	0698	0682	0667	0651	0635	0620	0604	0589
Feet	0	+10	+20	+30	+40	+50	+60	+70	+80	+90
Diff. in Log τ	0	−·0002	−·0003	−·0005	−·0006	−·0008	−·0009	−·0011	−·0013	−·0014

XXII. (1) Spherical Projectiles.

v	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.	12 in.
f. s.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
900	13	29	51	80	115	156	204	258	319	386	459
1000	18	40	71	110	159	216	282	357	441	534	635
1100	25	57	102	159	229	312	408	516	637	771	917
1200	33	75	134	209	301	409	534	676	835	1010	1202
1300	41	91	162	254	365	497	649	822	1015	1228	1461
1400	48	109	194	303	436	593	775	981	1211	1466	1744
1500	57	128	227	355	511	695	908	1149	1419	1716	2043
1600	65	147	261	408	588	800	1045	1322	1633	1976	2351
1700	74	167	296	463	666	907	1185	1499	1851	2240	2666
1800	83	187	332	518	746	1016	1327	1679	2073	2508	2985
1900	93	209	371	580	835	1137	1485	1880	2320	2808	3341
2000	104	235	417	652	939	1278	1669	2112	2607	3155	3754
2100	115	259	460	718	1035	1408	1839	2328	2874	3477	4138
2200	125	281	500	781	1124	1530	1999	2530	3123	3779	4497

(2) Ogival-headed Projectiles ($1\frac{1}{2}$ diameter).

v	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.	12 in.
f. s.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
100	0·1	0·2	0·3	0·5	0·7	0·9	1·2	1·5	1·9	2·3	2·7
200	0·3	0·7	1·2	1·9	2·7	3·7	4·8	6·1	7·5	9·1	10·8
300	0·7	1·5	2·7	4·2	6·1	8·3	10·8	13·7	16·9	20·4	24·3
400	1·2	2·7	4·8	7·5	10·8	14·7	19·3	24·4	30·1	36·4	43·3
500	1·9	4·2	7·5	11·8	16·9	23·0	30·1	38·1	47·0	56·9	67·7
600	2·7	6·1	10·8	16·9	24·3	33·1	43·3	54·8	67·6	81·8	97·3
700	3·7	8·3	14·7	23·0	33·2	45·1	58·9	74·6	92·1	111·4	132·6
800	4·8	10·8	19·2	30·1	43·3	58·9	76·9	97·4	120·2	145·4	173·1
900	6·7	15·0	26·7	41·7	60·0	81·6	106·6	134·9	166·5	201·6	239·9
1000	9·1	20·6	36·6	57·2	82·3	112·0	146·3	185·2	228·6	276·6	329·2
1100	17·7	39·8	70·7	110·5	159·1	216·6	282·9	358·0	442·0	534·8	636·5
1200	24	53	94	147	212	288	377	477	588	712	847
1300	30	67	119	187	269	366	478	605	747	903	1075
1400	36	81	143	224	323	439	574	726	897	1085	1291
1500	41	93	165	258	371	506	660	836	1032	1248	1486
1600	46	104	184	288	415	564	737	933	1151	1393	1658
1700	51	115	204	319	459	624	816	1032	1274	1542	1835
1800	56	126	224	351	505	687	897	1136	1402	1696	2019
1900	62	138	246	385	554	754	985	1246	1539	1862	2215
2000	68	153	272	426	613	834	1090	1379	1702	2060	2451
2100	77	173	308	482	694	944	1233	1561	1927	2332	2775
2200	87	196	348	544	784	1066	1393	1763	2177	2634	3134
2300	94	212	376	588	846	1152	1504	1904	2351	2844	3385
2400	98	220	392	612	881	1200	1567	1983	2448	2962	3525
2500	103	231	411	642	924	1258	1643	2079	2567	3106	3697
2600	112	253	450	703	1012	1378	1800	2278	2812	3403	4050
2700	126	282	502	784	1130	1537	2008	2541	3138	3796	4518
2800	140	314	559	873	1257	1711	2235	2829	3493	4226	5029

XXIII. S_v for Spherical Projectiles. ($w = 534{\cdot}22$ grams).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
40	150	171	192	213	234	255	276	296	317	338	21
41	359	379	400	420	441	461	481	501	522	542	20
42	562	582	602	622	642	662	682	702	722	742	20
43	761	781	800	820	839	859	878	897	917	936	19
44	955	974	994	1013	1032	1051	1070	1089	1108	1127	19
45	1146	1164	1183	1202	1221	1239	1258	1276	1295	1313	19
46	1331	1350	1368	1387	1405	1423	1441	1459	1477	1495	18
47	1513	1531	1549	1567	1585	1602	1620	1638	1656	1673	18
48	1691	1709	1726	1744	1761	1779	1796	1814	1831	1848	17
49	1866	1883	1900	1917	1934	1951	1968	1985	2002	2019	17
50	2036	2053	2070	2086	2103	2120	2137	2154	2171	2188	17
51	2204	2221	2237	2254	2270	2287	2303	2319	2336	2352	16
52	2368	2384	2401	2417	2433	2449	2465	2481	2497	2513	16
53	2529	2545	2561	2577	2593	2608	2624	2640	2656	2671	16
54	2687	2703	2718	2734	2749	2765	2780	2796	2811	2827	16
55	2842	2858	2873	2888	2904	2919	2934	2949	2965	2980	15
56	2995	3010	3025	3040	3055	3070	3085	3099	3114	3129	15
57	3144	3159	3174	3189	3204	3218	3233	3248	3262	3277	15
58	3291	3306	3320	3335	3349	3364	3378	3393	3407	3421	14
59	3436	3450	3464	3478	3493	3507	3521	3535	3550	3564	14
60	3578	3592	3606	3620	3634	3648	3662	3676	3690	3704	14
61	3718	3731	3745	3759	3773	3786	3800	3814	3828	3841	14
62	3855	3869	3883	3896	3910	3924	3937	3951	3964	3977	14
63	3991	4004	4017	4031	4044	4058	4071	4084	4098	4111	13
64	4124	4137	4150	4163	4176	4189	4203	4216	4229	4242	13
65	4255	4268	4281	4294	4307	4319	4332	4345	4358	4371	13
66	4384	4397	4410	4422	4435	4448	4461	4473	4486	4499	13
67	4511	4524	4536	4549	4561	4574	4586	4599	4611	4624	13
68	4636	4649	4661	4674	4686	4698	4711	4723	4735	4747	12
69	4760	4772	4784	4796	4809	4821	4833	4845	4857	4869	12
70	4881	4893	4905	4917	4929	4941	4953	4965	4977	4989	12
71	5001	5013	5025	5037	5049	5060	5072	5084	5096	5107	12
72	5119	5131	5143	5154	5166	5178	5190	5201	5213	5225	12
73	5236	5248	5259	5271	5282	5294	5305	5317	5328	5340	12
74	5351	5363	5374	5385	5397	5408	5420	5431	5442	5453	11
75	5465	5476	5487	5498	5510	5521	5532	5543	5555	5566	11
76	5577	5588	5599	5610	5621	5632	5643	5654	5665	5676	11
77	5687	5698	5709	5720	5731	5742	5753	5764	5775	5785	11
78	5796	5807	5818	5828	5839	5850	5861	5871	5882	5893	11
79	5904	5914	5925	5936	5947	5957	5968	5979	5989	6000	11
80	6010	6021	6031	6042	6052	6063	6073	6084	6094	6105	11
81	6115	6126	6136	6147	6157	6168	6178	6188	6199	6209	10
82	6219	6229	6240	6250	6260	6270	6281	6291	6301	6311	10
83	6322	6332	6342	6352	6362	6372	6382	6392	6403	6413	10
84	6423	6433	6443	6453	6463	6473	6483	6493	6503	6512	10
85	6522	6532	6542	6552	6561	6571	6581	6591	6600	6610	10
86	6619	6629	6639	6648	6658	6667	6677	6686	6696	6705	10
87	6714	6724	6733	6742	6752	6761	6770	6779	6789	6798	9
88	6807	6816	6825	6835	6844	6853	6862	6871	6880	6889	9
89	6898	6907	6916	6925	6933	6942	6951	6960	6969	6978	9
90	6986	6995	7004	7013	7021	7030	7039	7046	7056	7064	9

XXIII. S_v for Spherical Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
91	7073	7082	7090	7099	7107	7116	7124	7133	7141	7149	8
92	7158	7166	7175	7183	7191	7200	7208	7216	7225	7233	8
93	7241	7249	7257	7266	7274	7282	7290	7298	7306	7314	8
94	7322	7330	7338	7346	7354	7362	7370	7378	7386	7394	8
95	7402	7409	7417	7425	7433	7441	7448	7456	7464	7472	8
96	7479	7487	7495	7502	7510	7518	7525	7533	7541	7548	8
97	7556	7563	7571	7578	7586	7593	7601	7608	7615	7623	7
98	7630	7638	7645	7652	7660	7667	7674	7681	7689	7696	7
99	7703	7710	7717	7725	7732	7739	7746	7753	7760	7767	7
100	7774	7781	7788	7795	7802	7809	7816	7823	7830	7837	7
101	7844	7851	7858	7864	7871	7878	7885	7892	7898	7905	7
102	7912	7918	7925	7932	7938	7945	7951	7958	7964	7971	7
103	7977	7984	7990	7997	8003	8010	8016	8022	8029	8035	6
104	8041	8047	8053	8060	8066	8072	8078	8084	8091	8097	6
105	8103	8109	8115	8121	8127	8133	8139	8145	8151	8157	6
106	8163	8169	8175	8180	8186	8192	8198	8204	8209	8215	6
107	8221	8227	8233	8238	8244	8250	8256	8261	8267	8272	6
108	8278	8284	8289	8295	8300	8306	8312	8317	8323	8328	6
109	8334	8339	8345	8350	8356	8361	8366	8372	8377	8383	5
110	8387·8	393·1	398·4	403·8	409·1	414·4	419·7	425·0	430·2	435·5	5·3
111	8440·8	446·0	451·2	456·5	461·7	466·9	472·1	477·2	482·4	487·5	5·2
112	492·7	497·8	502·9	508·1	513·2	518·3	523·4	528·4	533·5	538·5	5·1
113	543·6	548·6	553·6	558·7	563·7	568·7	573·7	578·6	583·6	588·5	5·0
114	593·5	598·4	603·3	608·3	613·2	618·1	623·0	627·9	632·7	637·6	4·9
115	642·5	647·3	652·1	657·0	661·8	666·6	671·4	676·2	680·9	685·7	4·8
116	8690·5	695·3	700·0	704·8	709·5	714·3	719·0	723·7	728·4	733·1	4·7
117	737·8	742·5	747·1	751·8	756·4	761·1	765·7	770·3	775·0	779·6	4·6
118	784·2	788·8	793·4	797·9	802·5	807·1	811·7	816·2	820·8	825·3	4·6
119	829·9	834·4	838·9	843·5	848·0	852·5	857·0	861·5	865·9	870·4	4·5
120	874·9	879·3	883·8	888·2	892·7	897·1	901·5	905·9	910·4	914·8	4·4
121	8919·2	923·6	928·0	932·4	936·8	941·2	945·6	949·9	954·3	958·6	4·4
122	963·0	967·3	971·6	976·0	980·3	984·6	988·9	993·2	997·5	*001·8	4·3
123	9006·1	010·4	014·7	019·0	023·3	027·6	031·9	036·1	040·4	044·6	4·3
124	048·9	053·1	057·3	061·5	065·7	069·9	074·1	078·3	082·5	086·7	4·2
125	090·9	095·1	099·3	103·5	107·7	111·9	116·1	120·2	124·4	128·5	4·1
126	9132·7	136·8	140·9	145·1	149·2	153·3	157·4	161·5	165·6	169·7	4·1
127	173·8	177·9	182·0	186·1	190·2	194·3	198·4	202·4	206·5	210·5	4·1
128	214·6	218·6	222·7	226·7	230·8	234·8	238·8	242·8	246·9	250·9	4·0
129	254·9	258·9	262·9	267·0	271·0	275·0	279·0	283·0	286·9	290·9	4·0
130	294·9	298·9	302·9	306·8	310·8	314·8	318·8	322·7	326·7	330·6	4·0
131	9334·6	338·5	342·4	346·4	350·3	354·2	358·1	362·0	365·9	369·8	3·9
132	373·7	377·6	381·5	385·4	389·3	393·2	397·1	400·9	404·8	408·6	3·9
133	412·5	416·4	420·2	424·1	427·9	431·8	435·6	439·4	443·3	447·1	3·8
134	450·9	454·7	458·5	462·3	466·1	469·9	473·7	477·5	481·2	485·0	3·8
135	488·8	492·6	496·4	500·1	503·9	507·7	511·4	515·2	518·9	522·7	3·8
136	9526·4	530·1	533·8	537·6	541·3	545·0	548·7	552·4	556·1	559·8	3·7
137	563·5	567·2	570·9	574·6	578·3	582·0	585·7	589·3	593·0	596·6	3·7
138	600·3	604·0	607·6	611·3	614·9	618·6	622·2	625·9	629·5	633·2	3·7
139	636·8	640·4	644·0	647·7	651·3	654·9	658·5	662·1	665·7	669·3	3·6
140	672·9	676·5	680·1	683·6	687·2	690·8	694·4	697·9	701·5	705·0	3·6

XXIII. S_v for Spherical Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
141	9708·6	712·2	715·7	719·3	722·8	726·4	729·9	733·5	737·0	740·6	3·6
142	744·1	747·6	751·1	754·6	758·1	761 6	765·1	768·6	772·1	775·6	3·5
143	779·1	782·6	786·1	789·5	793·0	796·5	800·0	803·4	806·9	810·3	3·5
144	813·8	817·3	820·7	824·2	827·6	831·1	834·5	838·0	841·4	844·9	3·5
145	848·3	851·7	855·1	858·5	861·9	865·3	868·7	872·1	875·5	878·9	3·4
146	9882·3	885·7	889·1	892·5	895·9	899·3	902·7	906·1	909·4	912·8	3·4
147	916·2	919·6	922·9	926·3	929·6	933·0	936·3	939·7	943·0	946·4	3·4
148	949·7	953·0	956·4	959·7	963·1	966·4	969·7	973·0	976·4	979·7	3·3
149	983·0	986·3	989·6	992·9	996·2	999·5	*002·8	*006·1	*009·4	*012·7	3·3
150	10016·0	019·3	022·6	025·8	029·1	032 4	035·7	038·9	042·2	045·4	3·3
151	10048·7	051·9	055·2	058·4	061·7	064·9	068·1	071·4	074·6	077·9	3·2
152	081·1	084·3	087·6	090·8	094·1	097·3	100·5	103·7	106·9	110·1	3·2
153	113·3	116·5	119·7	122·9	126·1	129·3	132·5	135·7	138·9	142·1	3·2
154	145·3	148·5	151·7	154·8	158·0	161·2	164·4	167·5	170·7	173·8	3·2
155	177·0	180·1	183·3	186·4	189·6	192·7	195·8	199·0	202·1	205·3	3·1
156	10208·4	211·5	214·7	217·8	221·0	224·1	227·2	230·3	233·5	236·6	3·1
157	239·7	242·8	245·9	249·0	252·1	255·2	258·3	261·4	264·5	267·6	3·1
158	270·7	273·8	276·9	279·9	283·0	286·1	289·2	292·3	295·3	298·4	3·1
159	301·5	304·6	307·6	310·7	313·7	316·8	319·8	322·9	325·9	329·0	3·1
160	332·0	335·0	338·1	341·1	344·2	347·2	350·2	353·2	356·3	359·3	3·0
161	10362·3	365·3	368·3	371·4	374·4	377·4	380·4	383·4	386·4	389·4	3·0
162	392·4	395·4	398·4	401·4	404·4	407·4	410·4	413·4	416·4	419·4	3·0
163	422·4	425·4	428·4	431·3	434·3	437·3	440·3	443·2	446·2	449·1	3·0
164	452·1	455·1	458·0	461·0	463·9	466·9	469·8	472·8	475·7	478·7	2·9
165	481·6	484·5	487·5	490·4	493·4	496·3	499·2	502·2	505·1	508·1	2·9
166	10511·0	513·9	516·8	519·8	522·7	525·6	528·5	531·4	534·3	537·2	2·9
167	540·1	543·0	545·9	548·8	551·7	554·6	557·5	560·4	563·3	566·2	2·9
168	569·1	572·0	574·9	577·7	580·6	583·5	586·4	589·3	592·1	595·0	2·9
169	597·9	600 8	603·6	606·5	609·3	612·2	615·1	617·9	620·8	623·6	2·9
170	626·5	629·3	632·2	635·0	637·9	640·7	643·5	646·4	649·2	652·1	2·8
171	10654·9	657·7	660·6	663·4	666·3	669·1	671·9	674·7	677·6	680·4	2·8
172	683·2	686·0	688·8	691·7	694·5	697·3	700·1	702·9	705·7	708·5	2·8
173	711·2	714·1	716·9	719·7	722·5	725·3	728·1	730·9	733·7	736·5	2·8
174	739·3	742·1	744·9	747·6	750·4	753·2	756·0	758·8	761·5	764·3	2·8
175	767·1	769·9	772·6	775·4	778·1	780·9	783·7	786·4	789·2	791·9	2·8
176	10794·7	797·5	800·2	803·0	805·7	808·5	811·2	814·0	816·7	819·5	2·8
177	822·2	824·9	827·7	830·4	833·2	835·9	838·6	841·4	844·1	846·9	2·7
178	849·6	852·3	855·0	857·8	860·5	863·2	865·9	868·6	871·4	874·1	2·7
179	876·8	879·5	882·2	884·9	887·6	890·3	893·0	895·7	898·4	901·1	2·7
180	903·8	906·5	909·2	911·9	914·6	917·3	920 0	922·7	925·3	928·0	2·7
181	10930·7	933·4	936·1	938·7	941·4	944·1	946·8	949·5	952·1	954·8	2·7
182	957·5	960·2	962·8	965·5	968·1	970·8	973·5	976·1	978·8	981·4	2·7
183	984·1	986·8	989·4	992·1	994·7	997·4	*000·0	*002·7	*005·3	*008 0	2·7
184	11010 6	013·2	015·9	018·5	021·2	023·8	026·4	029·0	031·7	034·3	2·6
185	036·9	039·5	042·1	044·8	047·4	050·0	052·6	055·2	057·9	060·5	2·6
186	11063·1	065·7	068·3	070·9	073·5	076·1	078·7	081·3	083·9	086·5	2·6
187	089·1	091·7	094·3	096·8	099·4	102·0	104·6	107·2	109·7	112·3	2·6
188	114·9	117·5	120·1	122·6	125·2	127·8	130·4	132·9	135·5	138·0	2·6
189	140·6	143·2	145·7	148·3	150·8	153·4	155·9	158·5	161·0	163·6	2·6
190	166·1	168·6	171·2	173·7	176·3	178·8	181·3	183·9	186·4	189·0	2·5

XXIII. S_v for Spherical Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
191	11 191·5	194·0	196·5	199·1	201·6	204·1	206·6	209·1	211·7	214·2	2·5
192	216·7	219·2	221·7	224·2	226·7	229·2	231·7	234·2	236·7	239·2	2·5
193	241·7	244·2	246·7	249·1	251·6	254·1	256·6	259·0	261·5	263·9	2·5
194	266·4	268·9	271·4	273·8	276·3	278·8	281·3	283·7	286·2	288·6	2 5
195	291·1	293·6	296·0	298·5	300·9	303·4	305·9	308·3	310·8	313·2	2·5
196	11 315·7	318·1	320·6	323·0	325·5	327·9	330·3	332·8	335·2	337·7	2·4
197	340·1	342·5	344·9	347·4	349·8	352·2	354·6	357·0	359·5	361·9	2·4
198	364·3	366·7	369·1	371·5	373·9	376·3	378·7	381·1	383·5	385·9	2·4
199	388·3	390·7	393·1	395 5	397·9	400·3	402·7	405·1	407·4	409·8	2·4
200	412·2	414·6	417·0	419·3	421·7	424·1	426·5	428·8	431·2	433·5	2·4
201	11 435·9	438·3	440·7	443·0	445·4	447·8	450·2	452·5	454·9	457·2	2·4
202	459·6	461·9	464·3	466·6	469·0	471·3	473·7	476·0	478·4	480·7	2·3
203	483·1	485·4	487·8	490·1	492·5	494·8	497·1	499·4	501·8	504·1	2·3
204	506·4	508·7	511·0	513·4	515·7	518·0	520·3	522·6	525·0	527·3	2·3
205	529·6	531·9	534·2	536·6	538·9	541·2	543·5	545·8	548·2	550·5	2·3
206	11 552·8	555·1	557·4	559·7	562·0	564·3	566·6	568·9	571·2	573·5	2·3
207	575·8	578·1	580·4	582·6	584·9	587·2	589·5	591·8	594·1	596·4	2·3
208	598·7	601·0	603·3	605·5	607·8	610·1	612·4	614·7	616·9	619·2	2·3
209	621·5	623·8	626·1	628·3	630·6	632·9	635·2	637·5	639·7	642·0	2·3
210	644·3	646·6	648·8	651·1	653·3	655·6	657·9	660·1	662·4	664·6	2·3
211	11 666·9	669·2	671·4	673·7	675·9	678·2	680·5	682·7	685·0	687·2	2·3
212	689·5	691·7	694·0	696·2	698·5	700·7	703·0	705·2	707·5	709·7	2·2
213	712·0	714·2	716·5	718·7	721·0	723·2	725·4	727·7	729·9	732·2	2·2
214	734·4	736·6	738·8	741·1	743·3	745·5	747·7	750 0	752·2	754·5	2·2
215	756·7	758·9	761·1	763·4	765·6	767·8	770·0	772·3	774·5	776·8	2·2
216	11 779·0	781·2	783·4	785·7	787·9	790·1	792·3	794·5	796·8	799·0	2·2
217	801·2	803·4	805·6	807·8	810·0	812·2	814·4	816·6	818·8	821·0	2·2
218	823·2	825·4	827·6	829·8	832·0	834·2	836·4	838·6	840·8	843·0	2·2
219	845·2	847·4	849·6	851·8	854·0	856·2	858·4	860·6	862·8	865·0	2·2
220	867·2	869·4	871·6	873·7	875·9	878·1	880·3	882·5	884·6	886·8	2·2
221	11 889·0	891·2	893·4	895·5	897·7	899·9	902·1	904·2	906·4	908·5	2·2
222	910·7	912·9	915·1	917·2	919·4	921·6	923·8	926·0	928·1	930·3	2·2
223	932·5	934·7	936·8	939·0	941·1	943·3	945·5	947·6	949·8	951·9	2·2
224	954·1	956·3	958·4	960·6	962·7	964·9	967·0	969·2	971·3	973·5	2·2
225	975·6	977·7	979·9	982·0	984·2	986·3	988·5	990·6	992·8	994·9	2·1
226	11 997·1	999·2	*001·4	*003·5	*005·7	*007·8	*009·9	*012·1	*014·2	*016·4	2·1
227	12 018·5	020·6	022·7	024·9	027·0	029·1	031·2	033·4	035·5	037·7	2·1
228	039·8	041·9	044·0	046·2	048·3	050·4	052·5	054·6	056·8	058·9	2·1
229	061·0	063 1	065·2	067·4	069·5	071·6	073·7	075·8	077·9	080·0	2·1
230	082·1	084·2	086·3	088·5	090·6	092·7	094·8	096·9	099·1	101·2	2·1

XXIV. T_v for Spherical Projectiles. ($w = 534·22$ grams).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
40	4·227	4·280	4·333	4·385	4·437	4·488	4·540	4·591	4·642	4·693	52
41	4·743	4·793	4·843	4·893	4·942	4·991	5·040	5·089	5·138	5·186	49
42	5·234	5·282	5·330	5·377	5·424	5·471	5·517	5·564	5·610	5·656	47
43	5·702	5·747	5·793	5·838	5·883	5·928	5·972	6·017	6·061	6·105	45
44	6·149	6·192	6·236	6·279	6·322	6·365	6·407	6·450	6·492	6·534	43
45	6·576	6·618	6·659	6·701	6·742	6·783	6·824	6·864	6·905	6·945	41
46	6·985	7·025	7·064	7·104	7·143	7·182	7·221	7·260	7·298	7·337	39
47	7·375	7·413	7·451	7·489	7·527	7·565	7·602	7·640	7·677	7·714	38
48	7·751	7·787	7·824	7·860	7·896	7·932	7·968	8·004	8·039	8·075	36
49	8·110	8·145	8·180	8·215	8·250	8·284	8·319	8·353	8·387	8·421	35
50	8·455	8·489	8·522	8·556	8·589	8·622	8·655	8·688	8·721	8·754	34
51	8·786	8·819	8·851	8·883	8·915	8·947	8·978	9·010	9·042	9·073	32
52	9·105	9·136	9·167	9·198	9·229	9·260	9·291	9·321	9·352	9·382	31
53	9·412	9·442	9·472	9·502	9·532	9·561	9·591	9·620	9·649	9·678	30
54	9·707	9·736	9·765	9·794	9·823	9·851	9·880	9·908	9·936	9·964	29
55	9·992	*0·020	*0·048	*0·076	*0·104	*0·131	*0·159	*0·186	*0·213	*0·240	28
56	1 0·267	0·294	0·321	0·348	0·375	0·401	0·428	0·454	0·480	0·506	27
57	0·532	0·558	0·584	0·610	0·636	0·661	0·687	0·712	0·738	0·763	26
58	0·788	0·813	0·838	0·862	0·887	0·912	0·937	0·961	0·986	1·010	25
59	1·035	1·059	1·083	1·107	1·131	1·155	1·179	1·202	1·226	1·249	24
60	1·273	1·296	1·320	1·343	1·367	1·390	1·413	1·436	1·459	1·482	23
61	1 1·505	1·527	1·550	1·572	1·595	1·617	1·639	1·661	1·684	1·706	22
62	1·728	1·750	1·772	1·793	1·815	1·837	1·858	1·880	1·901	1·923	22
63	1·944	1·965	1·986	2·008	2·029	2·050	2·071	2·092	2·112	2·133	21
64	2·154	2·174	2·195	2·215	2·236	2·256	2·276	2·296	2·317	2·337	20
65	2·357	2·377	2·397	2·417	2·436	2·456	2·476	2·495	2·515	2·534	20
66	1 2·554	2·573	2·593	2·612	2·632	2·651	2·670	2·689	2·708	2·727	19
67	2·746	2·765	2·783	2·802	2·820	2·839	2·857	2·876	2·894	2·913	19
68	2·931	2·949	2·967	2·986	3·004	3·022	3·040	3·058	3·075	3·093	18
69	3·111	3·129	3·146	3·164	3·181	3·199	3·216	3·234	3·251	3·269	18
70	3·286	3·303	3·320	3·338	3·355	3·372	3·389	3·406	3·422	3·439	17
71	1 3·456	3·473	3·490	3·506	3·523	3·540	3·556	3·573	3·589	3·606	17
72	3·622	3·638	3·654	3·670	3·686	3·702	3·718	3·734	3·750	3·766	16
73	3·782	3·798	3·814	3·829	3·845	3·861	3·877	3·892	3·908	3·923	16
74	3·939	3·954	3·970	3·985	4·001	4·016	4·031	4·046	4·062	4·077	15
75	4·092	4·107	4·122	4·137	4·152	4·167	4·182	4·196	4·211	4·225	15
76	1 4·240	4·254	4·269	4·283	4·298	4·312	4·326	4·341	4·355	4·370	14
77	4·384	4·398	4·412	4·427	4·441	4·455	4·469	4·483	4·497	4·511	14
78	4·525	4·539	4·553	4·567	4·581	4·595	4·609	4·622	4·636	4·649	14
79	4·663	4·676	4·690	4·703	4·717	4·730	4·743	4·756	4·770	4·783	13
80	4·796	4·809	4·822	4·835	4·848	4·861	4·874	4·887	4·900	4·913	13
81	1 4·926	4·939	4·952	4·964	4·977	4·990	5·003	5·016	5·028	5·041	13
82	5·054	5·066	5·079	5·091	5·104	5·116	5·128	5·141	5·153	5·166	12
83	5·178	5·190	5·202	5·215	5·227	5·239	5·251	5·263	5·276	5·288	12
84	5·300	5·312	5·324	5·335	5·347	5·359	5·371	5·382	5·394	5·405	12
85	5·417	5·428	5·440	5·451	5·463	5·474	5·485	5·496	5·508	5·519	11

XXIV. T_v for Spherical Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
86	15·530	5·541	5·552	5·564	5·575	5·586	5·597	5·608	5·618	5·629	11
87	5·640	5·651	5·662	5·672	5·683	5·694	5·704	5·715	5·725	5·736	11
88	5·746	5·756	5·767	5·777	5·788	5·798	5·808	5·818	5·829	5·839	10
89	5·849	5·859	5·869	5·879	5·889	5·899	5·909	5·919	5·928	5·938	10
90	5·948	5·958	5·967	5·977	5·986	5·996	6·006	6·015	6·025	6·034	10
91	16·044	6·053	6·063	6·072	6·082	6·091	6·100	6·109	6·119	6·128	9
92	6·137	6·146	6·155	6·164	6·173	6·182	6·191	6·200	6·208	6·217	9
93	6·226	6·235	6·244	6·252	6·261	6·270	6·279	6·287	6·296	6·304	9
94	6·313	6·321	6·330	6·338	6·347	6·355	6·363	6·372	6·380	6·389	8
95	6·397	6·405	6·413	6·422	6·430	6·438	6·446	6·454	6·463	6·471	8
96	16·479	6·487	6·495	6·503	6·511	6·519	6·527	6·535	6·542	6·550	8
97	6·558	6·566	6·573	6·581	6·588	6·596	6·604	6·611	6·619	6·626	8
98	6·634	6·642	6·649	6·657	6·664	6·672	6·679	6·686	6·694	6·701	7
99	6·708	6·715	6·722	6·730	6·737	6·744	6·751	6·758	6·766	6·773	7
100	6·780	6·787	6·794	6·801	6·808	6·815	6·822	6·829	6·835	6·842	7
101	16·8491	8559	8627	8694	8761	8828	8895	8961	9027	9093	67
102	9158	9223	9288	9353	9417	9482	9546	9610	9673	9737	64
103	9800	9862	9925	9987	*0049	*0111	*0172	*0233	*0294	*0355	62
104	17·0416	0476	0536	0595	0655	0714	0773	0832	0890	0948	59
105	1006	1064	1121	1179	1236	1293	1350	1406	1463	1519	57
106	17·1575	1630	1686	1741	1796	1851	1905	1960	2014	2068	55
107	2122	2176	2229	2283	2336	2389	2442	2495	2547	2600	53
108	2652	2704	2756	2807	2859	2910	2961	3012	3062	3113	51
109	3163	3213	3263	3313	3363	3413	3462	3512	3561	3610	50
110	3659	3708	3756	3805	3853	3901	3949	3997	4044	4092	48
111	17·4139	4186	4233	4280	4326	4373	4419	4466	4512	4558	47
112	4604	4650	4696	4741	4787	4832	4877	4922	4967	5012	45
113	5057	5101	5145	5190	5234	5278	5322	5366	54 9	5453	44
114	5497	5540	5583	5626	5669	5712	5755	5797	5840	5882	43
115	5925	5967	6009	6050	6092	6134	6175	6216	6258	6299	42
116	17·6340	6381	6422	6462	6503	6544	6584	6625	6665	6706	41
117	6746	6786	6826	6865	6905	6945	6984	7023	7063	7102	40
118	7141	7180	7219	7257	7296	7335	7373	7412	7450	7489	39
119	7527	7565	7603	7640	7678	7716	7753	7791	7828	7866	38
120	7903	7940	7977	8014	8051	8088	8125	8161	8198	8234	37
121	17·8271	8307	8343	8380	8416	8452	8488	8524	8559	8595	36
122	8631	8666	8702	8737	8773	8808	8843	8878	8913	8948	35
123	8983	9018	9053	9087	9122	9157	9191	9226	9260	9295	35
124	9329	9363	9397	9431	9465	9499	9533	9566	9600	9633	34
125	9667	9700	9734	9767	9801	9834	9867	9900	9933	9966	33
126	17·9999	*0032	*0065	*0097	*0130	*0163	*0195	*0228	*0260	*0293	33
127	18·0325	0357	0389	0422	0454	0486	0518	0550	0581	0613	32
128	0645	0677	0708	0740	0771	0803	0834	0865	0897	0928	31
129	0959	0990	1021	1052	1083	1114	1145	1176	1206	1237	31
130	1268	1298	1329	1359	1390	1420	1450	1480	1511	1541	30
131	18·1571	1601	1631	1661	1691	1721	1751	1780	1810	1839	30
132	1869	1898	1928	1957	1987	2016	2045	2074	2104	2133	29
133	2162	2191	2220	2248	2277	2306	2335	2363	2392	2420	29
134	2449	2477	2506	2534	2563	2591	2619	2647	2676	2704	28
135	2732	2760	2788	2815	2843	2871	2899	2926	2954	2981	28

XXIV. T_v for Spherical Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
136	18·3009	3036	3063	3091	3118	3145	3172	3199	3227	3254	27
137	3281	3308	3335	3361	3388	3415	3442	3469	3495	3522	27
138	3549	3575	3602	3628	3655	3681	3707	3733	3760	3786	26
139	3812	3838	3864	3890	3916	3942	3968	3994	4019	4045	26
140	4071	4096	4122	4147	4173	4198	4223	4249	4274	4300	25
141	18·4325	4350	4375	4400	4425	4450	4475	4500	4525	4550	25
142	4575	4600	4624	4649	4673	4698	4722	4747	4771	4796	25
143	4820	4844	4869	4893	4918	4942	4966	4990	5015	5039	24
144	5063	5087	5111	5135	5159	5183	5207	5230	5254	5277	24
145	5301	5325	5348	5372	5395	5419	5442	5466	5489	5513	24
146	18·5536	5559	5582	5606	5629	5652	5675	5698	5721	5744	23
147	5767	5790	5813	5835	5858	5881	5904	5926	5949	5971	23
148	5994	6016	6039	6061	6084	6106	6128	6151	6173	6196	22
149	6218	6240	6262	6285	6307	6329	6351	6373	6395	6417	22
150	6439	6461	6483	6504	6526	6548	6570	6591	6613	6634	22
151	18·6656	6677	6699	6720	6742	6763	6784	6806	6827	6849	21
152	6870	6891	6912	6934	6955	6976	6997	7018	7039	7060	21
153	7081	7102	7123	7144	7165	7186	7207	7227	7248	7268	21
154	7289	7310	7330	7351	7371	7392	7412	7432	7453	7474	21
155	7494	7514	7535	7555	7576	7596	7616	7636	7657	7677	20
156	18·7697	7717	7737	7757	7777	7797	7817	7837	7856	7876	20
157	7896	7916	7936	7955	7975	7995	8015	8034	8054	8073	20
158	8093	8113	8132	8152	8171	8191	8210	8230	8249	8269	20
159	8288	8307	8326	8346	8365	8384	8403	8422	8441	8460	19
160	8479	8498	8517	8536	8555	8574	8593	8612	8630	8649	19
161	18·8668	8687	8705	8724	8742	8761	8780	8798	8817	8835	19
162	8854	8873	8891	8910	8928	8947	8965	8984	9002	9021	19
163	9039	9057	9075	9094	9112	9130	9148	9166	9184	9202	18
164	9220	9238	9256	9274	9292	9310	9328	9346	9364	9382	18
165	9400	9418	9436	9453	9471	9489	9507	9524	9542	9559	18
166	18·9577	9595	9612	9630	9647	9665	9682	9700	9717	9735	18
167	9752	9769	9787	9804	9822	9839	9856	9873	9891	9908	17
168	9925	9942	9959	9977	9994	*0011	*0028	*0045	*0062	*0079	17
169	19·0096	0113	0130	0147	0164	0181	0198	0215	0231	0248	17
170	0265	0282	0298	0315	0331	0348	0365	0381	0398	0414	17
171	19·0431	0448	0464	0481	0497	0514	0530	0547	0563	0580	17
172	0596	0612	0629	0645	0662	0678	0694	0710	0727	0743	16
173	0759	0775	0791	0808	0824	0840	0856	0872	0888	0904	16
174	0920	0936	0952	0968	0984	1000	1016	1032	1048	1064	16
175	1080	1096	1112	1127	1143	1159	1175	1190	1206	1221	16
176	19·1237	1253	1268	1284	1299	1315	1331	1346	1362	1377	16
177	1393	1408	1424	1439	1455	1470	1485	1501	1516	1532	15
178	1547	1562	1577	1593	1608	1623	1638	1653	1669	1684	15
179	1699	1714	1729	1745	1760	1775	1790	1805	1820	1835	15
180	1850	1865	1880	1895	1910	1925	1940	1955	1969	1984	15
181	19·1999	2014	2029	2043	2058	2073	2088	2103	2117	2132	15
182	2147	2162	2176	2191	2205	2220	2235	2249	2264	2278	15
183	2293	2307	2322	2336	2351	2365	2379	2394	2408	2423	14
184	2437	2451	2466	2480	2495	2509	2523	2537	2552	2566	14
185	2580	2594	2608	2622	2636	2650	2664	2678	2693	2707	14

XXIV. T_v for Spherical Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
186	19·2721	2735	2749	2763	2777	2791	2805	2819	2832	2846	14
187	2860	2874	2888	2901	2915	2929	2943	2957	2970	2984	14
188	2998	3012	3025	3039	3052	3066	3080	3093	3107	3120	14
189	3134	3148	3161	3175	3188	3202	3215	3229	3242	3256	14
190	3269	3282	3296	3309	3323	3336	3349	3362	3376	3389	13
191	19·3402	3415	3428	3442	3455	3468	3481	3494	3508	3521	13
192	3534	3547	3560	3573	3586	3599	3612	3625	3638	3651	13
193	3664	3677	3690	3702	3715	3728	3741	3754	3766	3779	13
194	3792	3805	3817	3830	3842	3855	3868	3880	3893	3905	13
195	3918	3931	3943	3956	3968	3981	3994	4006	4019	4031	13
196	19·4044	4056	4068	4081	4094	4106	4118	4131	4143	4156	12
197	4168	4180	4192	4205	4217	4229	4241	4253	4266	4278	12
198	4290	4302	4314	4327	4339	4351	4363	4375	4388	4400	12
199	4412	4424	4436	4448	4460	4472	4484	4496	4508	4520	12
200	4532	4544	4556	4567	4579	4591	4603	4615	4626	4638	12
201	19·4650	4662	4674	4685	4697	4709	4721	4732	4744	4755	12
202	4767	4779	4790	4802	4813	4825	4837	4848	4860	4871	12
203	4883	4895	4906	4918	4929	4941	4952	4964	4975	4987	12
204	4998	5009	5021	5032	5044	5055	5066	5078	5089	5101	11
205	5112	5123	5134	5146	5157	5168	5179	5190	5202	5213	11
206	19·5224	5235	5246	5258	5269	5280	5291	5302	5314	5325	11
207	5336	5347	5358	5369	5380	5391	5402	5413	5424	5435	11
208	5446	5457	5468	5479	5490	5501	5512	5523	5534	5545	11
209	5556	5567	5578	5588	5599	5610	5621	5632	5642	5653	11
210	5664	5675	5686	5696	5707	5718	5729	5740	5750	5761	11
211	19·5772	5783	5793	5804	5814	5825	5836	5846	5857	5867	11
212	5878	5889	5899	5910	5920	5931	5942	5952	5963	5973	11
213	5984	5995	6005	6016	6026	6037	6047	6058	6068	6079	11
214	6089	6099	6110	6120	6131	6141	6151	6162	6172	6183	10
215	6193	6203	6214	6224	6235	6245	6255	6266	6276	6287	10
216	19·6297	6307	6317	6328	6338	6348	6358	6368	6379	6389	10
217	6399	6409	6419	6430	6440	6450	6460	6470	6481	6491	10
218	6501	6511	6521	6531	6541	6551	6561	6571	6581	6591	10
219	6601	6611	6621	6631	6641	6651	6661	6671	6681	6691	10
220	6701	6711	6721	6731	6741	6751	6761	6771	6781	6791	10
221	19·6801	6811	6821	6830	6840	6850	6860	6869	6879	6888	10
222	6898	6908	6918	6927	6937	6947	6957	6967	6976	6986	10
223	6996	7006	7016	7025	7035	7045	7055	7064	7074	7083	10
224	7093	7103	7112	7122	7131	7141	7151	7160	7170	7179	10
225	7189	7198	7208	7217	7227	7236	7246	7255	7265	7274	9
226	19·7284	7293	7303	7312	7322	7331	7340	7350	7359	7369	9
227	7378	7387	7397	7406	7416	7425	7434	7444	7453	7463	9
228	7472	7481	7491	7500	7510	7519	7528	7537	7547	7556	9
229	7565	7574	7583	7593	7602	7611	7620	7629	7639	7648	9

XXV. S_v for Ogival-headed Projectiles. ($w = 534{\cdot}22$ grains.)

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
10	935	1099	1262	1423	1583	1741	1898	2053	2207	2359	158
11	2510	2660	2808	2955	3101	3245	3388	3530	3671	3811	145
12	3949	4086	4222	4357	4491	4624	4756	4886	5016	5144	133
13	5272	5399	5525	5649	5773	5896	6018	6139	6259	6378	123
14	6497	6614	6731	6847	6962	7077	7190	7303	7415	7526	114
15	7637	7747	7856	7964	8072	8179	8285	8391	8496	8600	107
16	8704	8807	8910	9012	9113	9213	9313	9412	9511	9609	101
17	9706	9803	9900	9996	*0091	*0185	*0279	*0373	*0466	*0559	95
18	1 0651	0742	0833	0924	1014	1104	1193	1281	1369	1457	90
19	1 1544	1631	1717	1803	1888	1973	2058	2142	2226	2309	85
20	2392	2474	2556	2638	2719	2800	2881	2961	3041	3120	81
21	3199	3278	3356	3434	3511	3588	3665	3741	3817	3892	77
22	1 3967	4042	4117	4191	4265	4338	4411	4484	4557	4630	74
23	4702	4774	4845	4916	4987	5058	5128	5198	5268	5337	71
24	5406	5475	5544	5612	5680	5747	5814	5881	5948	6014	68
25	1 6080	6146	6212	6277	6342	6407	6472	6537	6601	6665	65
26	6729	6793	6856	6919	6982	7044	7106	7168	7230	7291	62
27	7352	7413	7474	7535	7595	7655	7715	7775	7835	7895	60
28	1 7954	8013	8072	8131	8189	8247	8305	8363	8420	8477	58
29	8534	8591	8648	8704	8760	8816	8872	8928	8984	9039	56
30	9094	9149	9204	9259	9313	9367	9421	9475	9529	9583	54
31	1 9636	9689	9742	9795	9848	9901	9953	*0005	*0057	*0109	53
32	2 0161	0213	0264	0315	0366	0417	0468	0519	0569	0619	51
33	0669	0719	0769	0819	0869	0918	0967	1016	1065	1114	50
34	2 1163	1212	1260	1308	1356	1404	1452	1500	1548	1595	48
35	1642	1689	1736	1783	1830	1876	1923	1969	2015	2061	47
36	2107	2153	2199	2245	2290	2335	2380	2425	2470	2515	45
37	2 2560	2605	2650	2694	2738	2782	2826	2870	2914	2958	44
38	3001	3045	3088	3131	3174	3217	3260	3303	3346	3388	43
39	3430	3473	3515	3557	3599	3641	3683	3725	3767	3808	42
40	2 3849	3890	3931	3972	4013	4054	4095	4136	4177	4217	41
41	4257	4297	4337	4377	4417	4457	4497	4537	4577	4616	40
42	4655	4695	4734	4773	4812	4851	4890	4929	4968	5006	39
43	2 5044	5083	5121	5159	5197	5235	5273	5311	5349	5387	38
44	5424	5462	5499	5537	5574	5611	5648	5685	5722	5759	37
45	5796	5833	5869	5906	5942	5979	6015	6051	6087	6123	36
46	2 6159	6195	6230	6266	6301	6337	6372	6408	6443	6479	36
47	6514	6549	6584	6618	6653	6688	6723	6758	6792	6827	35
48	6862	6896	6930	6965	6999	7033	7067	7101	7135	7169	34
49	2 7203	7237	7270	7304	7337	7371	7404	7437	7471	7504	33
50	7537	7570	7603	7635	7668	7701	7734	7766	7799	7831	33
51	7864	7896	7928	7961	7993	8025	8057	8089	8121	8153	32
52	2 8185	8217	8248	8280	8311	8343	8374	8406	8437	8469	32
53	8500	8531	8562	8593	8624	8655	8686	8717	8747	8778	31
54	8809	8839	8870	8900	8931	8961	8991	9021	9052	9082	30
55	2 9112	9142	9172	9202	9232	9262	9292	9321	9351	9380	30
56	9410	9439	9469	9498	9528	9557	9586	9615	9645	9674	29
57	9703	9732	9761	9789	9818	9847	9876	9904	9933	9961	29

XXV. S_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
58	2 9990	*0018	*0047	*0075	*0104	*0132	*0160	*0188	*0217	*0245	28
59	3 0273	0301	0329	0357	0385	0413	0441	0468	0496	0523	28
60	0551	0578	0606	0633	0661	0688	0715	0742	0770	0797	27
61	3 0824	0851	0878	0905	0932	0959	0986	1013	1039	1066	27
62	1093	1120	1146	1173	1199	1226	1252	1278	1305	1331	26
63	1357	1383	1409	1436	1462	1488	1514	1540	1566	1592	26
64	3 1618	1644	1670	1695	1721	1747	1772	1798	1823	1849	26
65	1874	1899	1925	1950	1976	2001	2026	2051	2076	2101	25
66	2126	2151	2176	2201	2226	2251	2276	2301	2325	2350	25
67	3 2375	2400	2424	2449	2473	2498	2522	2547	2571	2596	25
68	2620	2644	2668	2693	2717	2741	2765	2789	2813	2837	24
69	2861	2885	2909	2932	2956	2980	3004	3028	3051	3075	24
70	3 3099	3123	3146	3170	3193	3217	3240	3263	3287	3310	23
71	3333	3356	3379	3403	3426	3449	3472	3495	3518	3541	23
72	3564	3587	3610	3632	3655	3678	3701	3724	3746	3769	23
73	3 3792	3815	3837	3860	3882	3905	3927	3950	3972	3995	23
74	4017	4039	4061	4084	4106	4128	4150	4172	4195	4217	22
75	4239	4261	4283	4305	4327	4349	4371	4393	4414	4436	22
76	3 4458	4480	4501	4523	4544	4566	4588	4609	4631	4652	22
77	4674	4695	4717	4738	4760	4781	4802	4823	4845	4866	21
78	4887	4908	4929	4951	4972	4993	5014	5035	5056	5077	21
79	3 5098	5119	5140	5161	5182	5202	5223	5244	5265	5285	21
80	5306	5327	5347	5368	5389	5409	5430	5450	5471	5491	20
81	5512	5532	5552	5573	5593	5613	5634	5654	5674	5694	20
82	3 5714	5734	5754	5775	5795	5815	5834	5854	5874	5894	20
83	5914	5933	5953	5973	5992	6012	6031	6051	6070	6089	19
84	6109	6128	6147	6166	6185	6204	6223	6242	6261	6280	19
85	3 6299	6318	6336	6355	6374	6393	6411	6430	6448	6467	19
86	6485	6503	6522	6540	6558	6576	6594	6612	6630	6648	18
87	6666	6684	6702	6720	6738	6756	6773	6791	6809	6826	18
88	3 6844	6861	6879	6896	6914	6931	6948	6966	6983	7000	17
89	7017	7034	7052	7069	7086	7103	7120	7136	7153	7170	17
90	7187	7204	7220	7237	7254	7271	7287	7303	7320	7336	17
91	3 7353	7369	7386	7402	7418	7435	7451	7467	7483	7499	16
92	7515	7531	7547	7563	7579	7595	7611	7627	7643	7658	16
93	7674	7690	7705	7721	7737	7752	7768	7783	7798	7814	16
94	3 7829	7845	7860	7875	7891	7906	7921	7936	7951	7966	15
95	7982	7997	8012	8027	8042	8057	8071	8086	8101	8116	15
96	8131	8145	8160	8175	8189	8204	8218	8233	8247	8262	15
97	3 8277	8291	8305	8320	8334	8348	8363	8377	8391	8405	14
98	8419	8433	8448	8462	8476	8490	8504	8518	8532	8546	14
99	8560	8573	8587	8601	8615	8628	8642	8656	8669	8683	14
100	3 8697	8710	8724	8737	8751	8764	8778	8791	8804	8818	13
101	8831	8844	8857	8871	8884	8897	8910	8923	8936	8949	13
102	8962	8975	8988	9000	9013	9026	9038	9051	9063	9076	13
103	3 9088	9100	9113	9125	9137	9149	9161	9172	9184	9196	12
104	9207	9219	9230	9241	9252	9263	9274	9285	9295	9306	11
105	9317	9327	9337	9347	9357	9367	9377	9387	9396	9406	10

XXV. S_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
106	39 415·7	425·0	434·2	443·5	452·7	462·0	471·0	479·9	488·9	497·8	9·1
107	506·8	515·5	524·3	533·0	541·8	550·5	559·0	567·5	576·0	584·5	8·6
108	593·0	601·2	609·5	617·7	626·0	634·3	642·4	650·5	658·6	666·7	8·2
109	39 674·8	682·8	690·7	698·6	706·5	714·4	722·2	730·0	737·8	745·6	7·9
110	753·4	761·1	768·8	776·5	784·2	791·9	799·5	807·1	814·6	822·2	7·6
111	829·7	837·1	844·5	851·9	859·3	866·8	874·1	881·4	888·8	896·1	7·4
112	39 903·5	910·7	918·0	925·2	932·5	939·8	946·9	954·1	961·3	968·5	7·2
113	975·7	982·8	989·9	997·0	*004·1	*011·2	*018·2	*025·2	*032·3	*039·3	7·1
114	40 046·4	053·4	060·4	067·4	074·4	081·4	088·3	095·2	102·2	109·1	7·0
115	40 116·1	122·9	129·8	136·6	143·5	150·4	157·2	164·0	170·8	177·6	6·8
116	184·4	191·1	197·9	204·6	211·4	218·2	224·9	231·6	238·3	245·0	6·7
117	251·7	258·3	265·0	271·6	278·2	284·9	291·5	298·0	304·6	311·2	6·6
118	40 317·8	324·3	330·8	337·3	343·9	350·4	356·8	363·3	369·8	376·2	6·5
119	382·7	389·1	395·5	401·9	408·4	414·8	421·1	427·5	433·9	440·2	6·4
120	446·6	452·9	459·2	465·5	471·9	478·2	484·4	490·7	497·0	503·2	6·3
121	40 509·5	515·7	521·9	528·1	534·3	540·5	546·6	552·8	559·0	565·1	6·2
122	571·3	577·4	583·5	589·6	595·7	601·8	607·8	613·9	620·0	626·0	6·1
123	632·1	638·1	644·1	650·1	656·1	662·1	668 0	674·0	680·0	685·9	6·0
124	40 691·9	697·8	703·7	709·6	715·6	721·5	727·3	733·2	739·1	744·9	5·9
125	750·8	756·6	762·4	768·2	774·0	779·8	785·5	791·3	797·1	802·8	5·8
126	808·6	814·3	820·1	825·8	831·5	837·3	843·0	848·7	854·4	860·1	5·7
127	40 865·8	871·4	877·0	882·6	888·3	893·9	899·5	905·1	910·7	916·3	5·6
128	921·9	927·4	933·0	938·5	944·0	949·6	955·1	960·6	966·1	971·6	5·5
129	977·1	982·5	988·0	993·5	998·9	*004·4	*009·8	*015·2	*020·6	*026·1	5·4
130	41 031·5	036·9	042·3	047·7	053·1	058·5	063·8	069·2	074·6	079·9	5·4
131	085·3	090·6	095·9	101·2	106·6	111·9	117·2	122·5	127·8	133·1	5·3
132	138 4	143·6	148·9	154·2	159·4	164·7	169·9	175·1	180·3	185·6	5·2
133	41 190·8	196·0	201·2	206·4	211·6	216·8	221·9	227·1	232·3	237·4	5·2
134	242·6	247·7	252·9	258·0	263·1	268·3	273·4	278·5	283·6	288·8	5·1
135	293·9	298·9	304·0	309·1	314·1	319·2	324·2	329·3	334·4	339·4	5·1
136	41 344·5	349·5	354·6	359·6	364·6	369·7	374·7	379·7	384·7	389·7	5·0
137	394·7	399·7	404·6	409·6	414·6	419·6	424·5	429·5	434·5	439·4	5·0
138	444·4	449·3	454·2	459·1	464·1	469·0	473·9	478·8	483·7	488·6	4·9
139	41 493·5	498·4	503·2	508·1	513·0	517·9	522·7	527·6	532·5	537·3	4·9
140	542·2	547·0	551·9	556·7	561·5	566·4	571·2	576·0	580·8	585·7	4·8
141	590·5	595·3	600·1	604·9	609·7	614·5	619·3	624·0	628·8	633·6	4·8
142	41 638·4	643·1	647·9	652·6	657·3	662·1	666·8	671·6	676·3	681·0	4·7
143	685·8	690·5	695·2	699·9	704·7	709·4	714·1	718·8	723·5	728·2	4·7
144	732·9	737·6	742·2	746·9	751·6	756·3	760·9	765·6	770·3	774·9	4·7
145	41 779·6	784·2	788·9	793·6	798·2	802·9	807·5	812·2	816·8	821·4	4·6
146	826·1	830·7	835·3	839·9	844·6	849·2	853·8	858·4	863·0	867·6	4·6
147	872·2	876·8	881·4	886·0	890·6	895·2	899·8	904·4	908·9	913·5	4·6
148	41 918·1	922·7	927·2	931·8	936·3	940·9	945·4	950·0	954·5	959·1	4·6
149	963·6	968·1	972·7	977·2	981·8	986·3	990·8	995·3	999·9	*004·4	4·5
150	42 008·9	013·4	017·9	022·5	027·0	031·5	036·0	040·5	044·9	049·4	4·5
151	42 053·9	058·4	062·9	067·3	071·8	076·3	080·8	085·3	089·7	094·2	4·5
152	098·7	103·2	107·6	112·1	116·5	121·0	125·4	129·8	134·3	138·7	4·4
153	143·1	147·5	151·9	156·4	160·8	165·2	169·6	174·1	178·5	183·0	4·4

XXV. S_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
154	42 187·4	191·8	196·3	200·7	205·2	209·6	214·0	218·4	222·9	227·3	4·4
155	231·7	236·1	240·5	245·0	249·4	253·8	258·2	262·6	266·9	271·3	4·4
156	275·7	280·1	284·5	288·8	293·2	297·6	302·0	306·4	310·7	315·1	4·4
157	42 319·5	323·9	328·2	332·6	336·9	341·3	345·7	350·0	354·4	358·7	4·4
158	363·1	367·4	371·8	376·1	380·5	384·8	389·1	393·5	397·8	402·2	4·3
159	406·5	410·8	415·1	419·5	423·8	428·1	432·4	436·7	441·1	445·4	4·3
160	42 449·7	454·0	458·3	462·6	466·9	471·2	475·5	479·8	484·1	488·4	4·3
161	492·7	497·0	501·3	505·6	509·9	514·2	518·5	522·8	527·0	531·3	4·3
162	535·6	539·9	544·2	548·4	552·7	557·0	561·3	565·5	569·8	574·0	4·3
163	42 578·3	582·5	586·8	591·0	595·3	599·5	603·7	608·0	612·2	616·5	4·2
164	620·7	624·9	629·2	633·4	637·7	641·9	646·1	650·3	654·6	658·8	4·2
165	663·0	667·2	671·4	675·7	679·9	684·1	688·3	692·5	696·8	701·0	4·2
166	42 705·2	709·4	713·6	717·8	722·0	726·2	730·4	734·6	738·8	743·0	4·2
167	747 2	751·4	755·6	759·7	763·9	768·1	772·3	776·5	780·6	784·8	4·2
168	789·0	793·2	797·3	801·5	805·6	809·8	814·0	818·1	822·3	826·4	4·2
169	42 830·6	834·8	838·9	843·1	847·2	851·4	855·5	859·7	863·8	868·0	4·2
170	872·1	876·2	880·4	884·5	888·7	892·8	896·9	901·1	905·2	909·4	4·1
171	913·5	917·6	921·7	925·9	930 0	934·1	938·2	942·3	946·5	950·6	4·1
172	42 954·7	958·8	962·9	967·1	971·2	975·3	979·4	983·5	987·6	991·7	4·1
173	995·8	999·9	*004·0	*008·1	*012·2	*016·3	*020·4	*024·5	*028·5	*032·6	4·1
174	43 036·7	040·8	044·9	048·9	053·0	057·1	061·2	065·3	069·3	073·4	4·1
175	43 077·5	081 6	085·6	089·7	093·7	097·8	101·9	105·9	110·0	114·1	4·1
176	118·1	122·1	126·2	130·2	134·3	138·3	142·3	146·4	150·4	154·5	4·0
177	158·5	162·5	166·5	170·6	174·6	178·6	182·6	186·6	190·7	194·7	4·0
178	43 198·7	202·7	206·7	210·7	214·7	218·7	222·7	226·7	230·8	234·8	4·0
179	238·8	242·8	246·8	250·8	254·8	258·8	262·8	266·8	270·7	274·7	4·0
180	278·7	282·7	286·7	290·6	294·6	298·6	302·6	306·6	310·5	314·5	4·0
181	43 318·5	322·5	326·5	330·4	334·4	338·4	342·4	346·3	350·3	354·2	4·0
182	358·2	362·2	366·1	370·1	374·0	378·0	381·9	385·9	389·8	393·8	4·0
183	397·7	401·6	405·6	409·5	413·5	417·4	421·3	425·3	429·2	433·2	3·9
184	43 437·1	441·0	444·9	448·9	452·8	456·7	460·6	464·5	468·5	472·4	3·9
185	476·3	480·2	484·1	488·0	491·9	495·8	499·7	503·6	507·5	511·4	3·9
186	515·3	519·2	523·1	526·9	530·8	534·7	538·6	542·5	546·3	550·2	3·9
187	43 554·1	558·0	561·9	565·7	569·6	573·5	577·4	581·2	585·1	588·9	3·9
188	592·8	596·7	600·5	604·4	608·2	612·1	615·9	619·8	623·6	627·5	3·9
189	631·3	635·1	639·0	642·8	646·7	650·5	654·3	658·2	662·0	665·9	3·8
190	43 669·7	673·5	677·4	681·2	685·1	688·9	692·7	696·5	700·4	704·2	3·8
191	708·0	711·8	715·6	719·5	723·3	727·1	730·9	734·7	738·6	742·4	3·8
192	746·2	750·0	753·8	757·6	761·4	765·2	769·0	772·8	776·6	780·4	3·8
193	43 784·2	788·0	791·8	795·6	799·4	803·2	807·0	810·8	814·5	818·3	3·8
194	822·1	825·9	829·6	833·4	837·1	840·9	844·7	848·4	852·2	855·9	3·8
195	859·7	863·5	867·2	871·0	874·7	878·5	882·2	886·0	889·7	893·5	3·8
196	43 897·2	900·9	904 7	908·4	912·2	915·9	919·6	923·3	927·1	930·8	3·7
197	934·5	938·2	941·9	945·7	949·4	953·1	956·8	960·5	964·2	967·9	3·7
198	971·6	975·3	979·0	982·6	986·3	990·0	993·7	997·4	*001·0	*004·7	3·7

XXV. S_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
199	44 008·4	012·1	015·7	019·4	023·0	026·7	030·4	034·0	037·7	041·3	3·7
200	045·0	048·6	052·3	055·9	059·6	063·2	066·8	070·5	074·1	077·8	3·6
201	081·4	085·0	088·6	092·3	095·9	099·5	103·1	106·7	110·4	114·0	3·6
202	44 117·6	121·2	124·8	128·4	132·0	135·6	139·2	142·8	146·3	149·9	3·6
203	153·5	157·1	160·7	164·2	167·8	171·4	175·0	178·5	182·1	185·6	3·6
204	189·2	192·7	196·3	199·8	203·4	206·9	210·4	213·9	217·5	221·0	3·5
205	44 224·5	228·0	231·5	235·1	238·6	242·1	245·6	249·1	252·6	256·1	3·5
206	259·6	263·1	266·6	270·1	273·6	277·1	280·6	284·1	287·5	291·0	3·5
207	294·5	298·0	301·4	304·9	308·3	311·8	315·2	318·7	322·1	325·6	3·5
208	44 329·0	332·4	335·9	339·3	342·8	346·2	349·6	353·0	356·5	359·9	3·4
209	363·3	366·7	370·1	373·5	376·9	380·3	383·7	387·1	390·4	393·8	3·4
210	397·2	400·6	404·0	407·3	410·7	414·1	417·5	420·8	424·2	427·5	3·4
211	44 430·9	434·3	437·6	441·0	444·3	447·7	451·0	454·4	457·7	461·1	3·4
212	464·4	467·7	471·0	474·4	477·7	481·0	484·3	487·6	490·9	494·2	3·3
213	497·5	500·8	504·1	507·4	510·7	514·0	517·3	520·6	523·8	527·1	3·3
214	44 530·4	533·7	537·0	540·2	543·5	546·8	550·1	553·3	556·6	559·8	3·3
215	563·1	566·4	569·6	572·9	576·1	579·4	582·6	585·8	589·1	592·3	3·2
216	595·5	598·7	601·9	605·2	608·4	611·6	614·8	618·0	621·3	624·5	3·2
217	44 627·7	630·9	634·1	637·3	640·5	643·7	646·9	650·1	653·2	656·4	3·2
218	659·6	662·8	666·0	669·1	672·3	675·5	678·7	681·8	685·0	688·1	3·2
219	691·3	694·5	697·6	700·8	703·9	707·1	710·2	713·4	716·5	719·7	3·2
220	44 722·8	725·9	729·1	732·2	735·4	738·5	741·6	744·7	747·9	751·0	3·1
221	754·1	757·2	760·3	763·5	766·6	769·7	772·8	775·9	779·1	782·2	3·1
222	785·3	788·4	791·5	794·6	797·7	800·8	803·9	807·0	810·1	813·2	3·1
223	44 816·3	819·4	822·5	825·5	828·6	831·7	834·8	837·9	840·9	844·0	3·1
224	847·1	850·2	853·2	856·3	859·3	862·4	865·5	868·5	871·6	874·6	3·1
225	877·7	880·8	883·8	886·9	889·9	893·0	896·1	899·1	902·2	905·2	3·1
226	44 908·3	911·3	914·4	917·4	920·5	923·5	926·5	929·6	932·6	935·7	3·0
227	938·7	941·7	944·8	947·8	950·9	953·9	957·0	960·0	963·1	966·1	3·0
228	969·2	972·2	975·3	978·3	981·4	984·4	987·4	990·5	993·5	996·6	3·0
229	44 999·6	*002·6	*005·7	*008·7	*011·8	*014·8	*017·8	*020·9	*023·9	*027·0	3·0
230	45 030·0	033·0	036·1	039·1	042·2	045·2	048·2	051·3	054·3	057·4	3·0
231	060·4	063·4	066·4	069·5	072·5	075·5	078·5	081·6	084·6	087·7	3·0
232	45 090·7	093·7	096·8	099·8	102·9	105·9	108·9	112·0	115·0	118·1	3·0
233	121·1	124·1	127·2	130·2	133·3	136·3	139·3	142·3	145·4	148·4	3·0
234	151·4	154·4	157·5	160·5	163·6	166·6	169·6	172·6	175·7	178·7	3·0
235	45 181·7	184·7	187·8	190·8	193·9	196·9	199·9	203·0	206·0	209·1	3·0
236	212·1	215·1	218·2	221·2	224·3	227·3	230·3	233·4	236·4	239·5	3·0
237	242·5	245·5	248·6	251·6	254·7	257·7	260·7	263·8	266·8	269·9	3·0
238	45 272·9	275·9	279·0	282·0	285·1	288·1	291·2	294·2	297·3	300·3	3·0
239	303·4	306·4	309·5	312·5	315·6	318·6	321·6	324·7	327·7	330·8	3·0
240	333·8	336·8	339·9	342·9	346·0	349·0	352·1	355·1	358·2	361·2	3·0
241	45 364·3	367·3	370·4	373·4	376·5	379·5	382·6	385·6	388·7	391·7	3·0
242	394·8	397·8	400·9	403·9	407·0	410·0	413·0	416·1	419·1	422·2	3·0
243	425·2	428·2	431·3	434·3	437·4	440·4	443·5	446·5	449·6	452·6	3·0

XXV. S_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	+
244	45 455·7	458·7	461·8	464·8	467·9	470·9	474·0	477·0	480·1	483·1	3·0
245	486·2	489·2	492·3	495·3	498·4	501·4	504·4	507·5	510·5	513·6	3·0
246	516·6	519·6	522·7	525·7	528·8	531·8	534·8	537·9	540·9	544·0	3·0
247	45 547·0	550·0	553·1	556·1	559·2	562·2	565·2	568·3	571·3	574·4	3·0
248	577·4	580·4	583·5	586·5	589·6	592·6	595·6	598·7	601·7	604·8	3·0
249	607·8	610·8	613·8	616·9	619·9	622·9	625·9	629·0	632·0	635·1	3·0
250	45 638·1	641·1	644·1	647·2	650·2	653·2	656·2	659·2	662·3	665·3	3·0
251	668·3	671·3	674·3	677·3	680·3	683·3	686·3	689·3	692·3	695·3	3·0
252	698·3	701·3	704·3	707·3	710·3	713·3	716·3	719·3	722·3	725·3	3·0
253	45 728·3	731·2	734·2	737·2	740·2	743·2	746·2	749·1	752·1	755·0	3·0
254	758·0	761·0	763·9	766·9	769·8	772·8	775·8	778·7	781·7	784·6	3·0
255	787·6	790·6	793·5	796·5	799·4	802·4	805·3	808·3	811·2	814·2	3·0
256	45 817·1	820·0	823·0	825·9	828·9	831·8	834·7	837·6	840·6	843·5	2·9
257	846·4	849·3	852·2	855·2	858·1	861·0	863·9	866·8	869·7	872·6	2·9
258	875·5	878·4	881·3	884·2	887·1	890·0	892·9	895·8	898·7	901·6	2·9
259	45 904·5	907·4	910·3	913·2	916·1	919·0	921·9	924·8	927·6	930·5	2·9
260	933·4	936·3	939·1	942·0	944·8	947·7	950·6	953·4	956·3	959·1	2·9
261	962·0	964·9	967·7	970·6	973·4	976·3	979·1	982·0	984·8	987·7	2·9
262	45 990·5	993·3	996·1	999·0	*001·8	*004·6	*007·4	*010·2	*013·1	*015·9	2·8
263	46 018·7	021·5	024·3	027·1	029·9	032·7	035·5	038·3	041·1	043·9	2·8
264	046·7	049·5	052·3	055·1	057·9	060·7	063·5	066·3	069·0	071·8	2·8
265	46 074·6	077·4	080·1	082·9	085·6	088·4	091·2	093·9	096·7	099·4	2·8
266	102·2	104·9	107·7	110·4	113·2	115·9	118·6	121·4	124·1	126·9	2·7
267	129·6	132·3	135·0	137·8	140·5	143·2	145·9	148·6	151·3	154·0	2·7
268	46 156·7	159·4	162·1	164·8	167·5	170·2	172·9	175·6	178·3	181·0	2·7
269	183·7	186·4	189·1	191·8	194·5	197·2	199·9	202·6	205·2	207·9	2·7
270	210·6	213·3	215·9	218·6	221·2	223·9	226·6	229·2	231·9	234·5	2·7
271	46 237·2	239·9	242·5	245·2	247·8	250·5	253·1	255·8	258·4	261·1	2·7
272	263·7	266·3	268·9	271·6	274·2	276·8	279·4	282·0	284·7	287·3	2·6
273	289·9	292·5	295·1	297·8	300·4	303·0	305·6	308·2	310·8	313·4	2·6
274	46 316·0	318·6	321·2	323·8	326·4	329·0	331·6	334·2	336·8	339·4	2·6
275	342·0	344·6	347·2	349·7	352·3	354·9	357·5	360·0	362·6	365·1	2·6
276	367·7	370·3	372·8	375·4	377·9	380·5	383·1	385·6	388·2	390·7	2·6
277	46 393·3	395·8	398·4	400·9	403·5	406·0	408·5	411·0	413·6	416·1	2·5
278	418·6	421·1	423·6	426·2	428·7	431·2	433·7	436·2	438·8	441·3	2·5
279	443·8	446·3	448·8	451·3	453·8	456·3	458·8	461·3	463·8	466·3	2·5
280	46 468·8	471·3	473·8	476·2	478·7	481·2	483·7	486·2	488·6	491·1	2·5
281	493·6	496·1	498·6	501·0	503·5	506·0	508·5	510·9	513·4	515·8	2·5
282	518·3	520·7	523·2	525·6	528·1	530·5	532·9	535·4	537·8	540·3	2·4
283	46 542·7	545·1	547·6	550·0	552·5	554·9	557·3	559·7	562·2	564·6	2·4
284	567·0	569·4	571·8	574·3	576·7	579·1	581·5	583·9	586·4	588·8	2·4
285	591·2	593·6	596·0	598·4	600·8	603·2	605·6	608·0	610·4	612·8	2·4
286	46 615·2	617·6	620·0	622·3	624·7	627·1	629·5	631·9	634·2	636·6	2·4
287	639·0	641·4	643·7	646·1	648·4	650·8	653·2	655·5	657·9	660·2	2·4
288	662·6	664·9	667·3	669·6	672·0	674·3	676·6	679·0	681·3	683·7	2·3
289	46 686·0	688·3	690·7	693·0	695·4	697·7	700·0	702·3	704·7	707·0	2·3
290	709·3	711·6	713·9	716·3	718·6	720·9	723·2	725·5	727·9	730·2	2·3

XXVI. T_v for Ogival-headed Projectiles. ($w = 534·22$ grains.)

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
10	9·9	11·6	13·2	14·8	16·4	17·9	19·4	20·9	22·3	23·7	1·5
11	25·1	26·5	27·8	29·1	30·3	31·5	32·8	34·0	35·2	36·4	1·2
12	37·5	38·6	39·7	40·8	41·9	43·0	44·0	45·1	46·1	47·1	1·1
13	48·1	49·0	50·0	50·9	51·9	52·8	53·7	54·6	55·4	56·3	0·9
14	57·2	58·0	58·8	59·6	60·4	61·2	62·0	62·7	63·5	64·2	0·8
15	65·0	65·7	66·4	67·2	67·9	68·6	69·3	69·9	70·6	71·2	0·7
16	71·91	72·55	73·18	73·81	74·43	75·04	75·64	76·24	76·83	77·41	·61
17	77·99	78·56	79·12	79 67	80·22	80·76	81·29	81·82	82·35	82·87	·54
18	83·39	83·90	84·40	84·90	85·39	85·88	86·36	86·84	87·31	87·78	·49
19	88·24	88·69	89·14	89·58	90·02	90·46	90·89	91·32	91·74	92·16	·44
20	92·57	92·98	93·39	93·79	94·19	94·59	94·98	95·37	95·75	96·13	·40
21	96·51	96·88	97·26	97·63	97·99	98·35	98·70	99·05	99·40	99·75	·36
22	1 00·09	00·43	00·77	01·10	01·43	01·76	02·08	02·40	02·72	03·04	·33
23	03·35	03·66	03·97	04·27	04·58	04·88	05·18	05·47	05·77	06·06	·30
24	06·35	06·64	06·92	07·20	07·48	07·75	08·03	08·30	08·57	08·84	·28
25	1 09·10	09·37	09·63	09 89	10·15	10·40	10·66	10·91	11·16	11·41	·26
26	11·65	11·90	12·14	12·38	12·62	12·85	13·09	13·32	13·55	13·78	·24
27	14 00	14·23	14·45	14·68	14·90	15·12	15·34	15·55	15·77	15·98	·22
28	1 16·19	16·40	16·61	16·81	17·02	17·22	17·43	17·63	17·83	18·03	·20
29	18·22	18·42	18·61	18·81	19·00	19·19	19·38	19·57	19·75	19·94	·19
30	20·12	20·31	20·49	20·67	20·85	21·02	21·20	21·38	21·56	21·73	·18
31	1 21·90	22·07	22·24	22·41	22·58	22·75	22·92	23·08	23·25	23·41	·17
32	23 57	23·73	23·89	24·05	24·21	24·36	24·52	24·67	24·83	24·98	·16
33	25·13	25·28	25·43	25·58	25·73	25·88	26·03	26·17	26·32	26·46	·15
34	1 26·60	26·74	26·88	27·02	27·16	27·30	27·44	27·58	27·71	27·85	·14
35	27·99	28·12	28·26	28·39	28·53	28·66	28·79	28·92	29·05	29·18	·13
36	29·31	29·44	29·57	29·69	29·82	29·94	30·07	30·19	30·31	30·43	·12
37	1 30·55	30·67	30·79	30·91	31·02	31·14	31·26	31·37	31·49	31·60	·12
38	31·72	31·83	31·95	32 06	32·18	32·29	32·40	32·51	32 62	32·73	·11
39	32·84	32·95	33·06	33·17	33·27	33·38	33·48	33·59	33·69	33·80	·11
40	1 33·90	34·00	34·11	34·21	34·31	34·41	34·51	34·61	34·71	34·81	·10
41	34·91	35·01	35·10	35·20	35·29	35·39	35·48	35·58	35·67	35·77	·10
42	35·86	35·96	36·05	36·14	36·24	36·33	36·42	36·51	36·60	36·69	·09
43	1 36·78	36·87	36·96	37·05	37·14	37·22	37·31	37·39	37·48	37·56	·09
44	37·65	37·73	37·82	37·90	37·99	38·07	38·16	38·24	38·32	38·41	·08
45	38·49	38·57	38·65	38·73	38·81	38·89	38·97	39·05	39·13	39·21	·08
46	1 39·29	39·36	39·44	39·52	39·59	39·67	39·75	39·82	39·90	39·97	·08
47	40·05	40·12	40·20	40 27	40·35	40·42	40·49	40·57	40 64	40·71	·07
48	40·78	40·86	40·93	41·00	41·07	41·14	41·21	41·28	41·35	41·42	·07
49	1 41·49	41·56	41 63	41·70	41·76	41·83	41·90	41·96	42·03	42·09	·07
50	42·16	42·23	42·29	42·36	42·42	42·49	42·56	42·62	42·69	42·75	·07
51	42·81	42·87	42·94	43·00	43·06	43·12	43·19	43·25	43·31	43·37	·06
52	14 3·430	3·491	3·552	3·613	3·673	3·733	3·793	3·853	3·912	3·971	·060
53	4·030	4·089	4·147	4·205	4·263	4·321	4·379	4·436	4·493	4·550	·058
54	4·607	4·664	4·720	4·776	4·832	4·888	4·944	4·999	5·054	5·109	·056
55	14 5·164	5·219	5·273	5·327	5·381	5·435	5·489	5·542	5·595	5·648	·054
56	5·701	5·754	5·806	5·858	5·910	5·962	6·014	6·065	6·117	6·168	·052
57	6·219	6·270	6·321	6·371	6·422	6·472	6·522	6·572	6·621	6·671	·050

XXVI. T_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
58	146·720	6·769	6·818	6·866	6·915	6·963	7·011	7·059	7·107	7·154	48
59	7·202	7·249	7·296	7·343	7·390	7·437	7·483	7·530	7·576	7·622	47
60	7·668	7·714	7·759	7·805	7·850	7·896	7·941	7·986	8·031	8·076	45
61	148·121	8·165	8·209	8·253	8·297	8·341	8·384	8·428	8·471	8·515	44
62	8·558	8·601	8·643	8·686	8·728	8·771	8·813	8·855	8·897	8·939	42
63	8·981	9·022	9·064	9·105	9·147	9·188	9·229	9·269	9·310	9·350	41
64	149·391	9·431	9·471	9·510	9·550	9·590	9·629	9·669	9·708	9·748	40
65	9·787	9·826	9·865	9·903	9·942	9·981	*0·019	*0·057	*0·096	*0·134	39
66	150·172	0·210	0·248	0·285	0·323	0·361	0·398	0·436	0·473	0·511	38
67	150·548	0·585	0·621	0·658	0·694	0·731	0·767	0·803	0·838	0·874	36
68	0·910	0·945	0·981	1·016	1·052	1·087	1·122	1·157	1·192	1·227	35
69	1·262	1·296	1·331	1·365	1·400	1·434	1·468	1·502	1·536	1·570	34
70	151·604	1·637	1·671	1·704	1·738	1·771	1·804	1·837	1·870	1·903	33
71	1·936	1·969	2·001	2·034	2·066	2·099	2·131	2·163	2·196	2·228	32
72	2·260	2·292	2·323	2·355	2·386	2·418	2·449	2·480	2·512	2·543	31
73	152·574	2·605	2·636	2·666	2·697	2·728	2·758	2·789	2·819	2·850	31
74	2·880	2·910	2·940	2·969	2·999	3·029	3·059	3·088	3·118	3·147	30
75	3·177	3·206	3·236	3·265	3·295	3·324	3·353	3·382	3·410	3·439	29
76	153·468	3·497	3·525	3·554	3·582	3·611	3·639	3·667	3·695	3·723	28
77	3·751	3·779	3·806	3·834	3·861	3·889	3·916	3·943	3·971	3·998	27
78	4·025	4·052	4·079	4·107	4·134	4·161	4·188	4·215	4·241	4·268	27
79	154·295	4·321	4·347	4·374	4·400	4·426	4·452	4·478	4·504	4·530	26
80	4·556	4·582	4·607	4·633	4·658	4·684	4·709	4·735	4·760	4·786	26
81	4·810	4·836	4·861	4·886	4·911	4·935	4·961	4·986	5·010	5·035	25
82	155·060	5·084	5·109	5·133	5·158	5·182	5·206	5·230	5·253	5·277	24
83	5·301	5·325	5·348	5·372	5·395	5·419	5·442	5·465	5·489	5·512	23
84	5·535	5·558	5·581	5·603	5·626	5·649	5·671	5·694	5·716	5·739	23
85	155·761	5·783	5·805	5·826	5·848	5·870	5·891	5·913	5·934	5·956	22
86	5·977	5·998	6·019	6·041	6·062	6·083	6·104	6·125	6·146	6·167	21
87	6·188	6·208	6·229	6·249	6·270	6·290	6·310	6·330	6·350	6·370	20
88	156·390	6·410	6·430	6·449	6·469	6·489	6·508	6·528	6·547	6·567	20
89	6·586	6·605	6·624	6·644	6·663	6·682	6·701	6·720	6·738	6·757	19
90	6·776	6·794	6·813	6·831	6·850	6·868	6·886	6·904	6·923	6·941	18
91	156·959	6·977	6·995	7·012	7·030	7·048	7·066	7·083	7·101	7·118	18
92	7·136	7·153	7·171	7·188	7·206	7·223	7·240	7·257	7·274	7·291	17
93	7·308	7·325	7·342	7·358	7·375	7·392	7·409	7·425	7·442	7·458	17
94	157·475	7·491	7·507	7·524	7·540	7·556	7·572	7·588	7·604	7·620	16
95	7·636	7·652	7·667	7·683	7·698	7·714	7·730	7·745	7·761	7·776	16
96	7·792	7·807	7·822	7·838	7·853	7·868	7·883	7·898	7·913	7·928	15
97	157·943	7·958	7·973	7·987	8·002	8·017	8·032	8·046	8·061	8·075	15
98	8·090	8·104	8·118	8·133	8·147	8·161	8·175	8·189	8·204	8·218	14
99	8·232	8·246	8·260	8·273	8·287	8·301	8·315	8·329	8·342	8·356	14
100	158·370	8·383	8·397	8·410	8·424	8·437	8·450	8·463	8·477	8·490	13
101	8·503	8·516	8·529	8·542	8·555	8·568	8·581	8·594	8·606	8·619	13
102	8·632	8·645	8·657	8·670	8·682	8·695	8·707	8·719	8·732	8·744	12
103	158·756	8·768	8·779	8·791	8·802	8·814	8·825	8·836	8·848	8·859	11
104	8·870	8·881	8·892	8·902	8·913	8·924	8·934	8·944	8·954	8·964	10
105	8·974	8·984	8·994	9·003	9·013	9·023	9·032	9·041	9·051	9·060	10

XXVI. T_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
106	159·069	9·078	9·087	9·095	9·104	9·113	9·121	9·130	9·138	9·147	9
107	9·155	9·163	9·171	9·179	9·187	9·195	9·203	9·211	9·218	9·226	8
108	9·234	9·242	9·250	9·257	9·265	9·273	9·281	9·288	9·296	9·303	8
109	159·311	9·318	9·325	9·333	9·340	9·347	9·354	9·361	9·368	9·375	7
110	9·382	9·389	9·396	9·403	9·410	9·417	9·424	9·431	9·437	9·444	7
111	9·451	9·458	9·464	9·471	9·477	9·484	9·491	9·497	9·504	9·510	7
112	159·517	9·523	9·530	9·536	9·543	9·549	9·555	9·562	9·568	9·575	6
113	9·581	9·587	9·594	9·600	9·607	9·613	9·619	9·625	9·632	9·638	6
114	9·644	9·650	9·656	9·662	9·668	9·674	9·680	9·686	9·692	9·698	6
115	159·704	9·710	9·716	9·722	9·728	9·734	9·740	9·746	9·752	9·758	6
116	9·764	9·770	9·776	9·781	9·787	9·793	9·799	9·805	9·810	9·816	6
117	9·822	9·828	9·833	9·839	9·844	9·850	9·856	9·861	9·867	9·872	6
118	159·878	9·883	9·889	9·894	9·900	9·905	9·910	9·916	9·921	9·927	5
119	9·932	9·937	9·943	9·948	9·954	9·959	9·964	9·970	9·976	9·981	5
120	9·986	9·991	9·996	*0·002	*0·007	*0·012	*0·017	*0·022	*0·028	*0·033	5
121	160·0381	0432	0483	0535	0586	0637	0688	0738	0789	0839	51
122	0890	0940	0990	1040	1090	1140	1189	1239	1288	1338	50
123	1387	1436	1484	1533	1581	1630	1678	1726	1775	1823	48
124	160·1871	1919	1966	2014	2061	2109	2156	2203	2250	2297	47
125	2344	2390	2437	2483	2529	2576	2622	2668	2713	2759	46
126	2805	2850	2896	2941	2987	3032	3077	3122	3166	3211	45
127	160·3256	3300	3344	3389	3433	3477	3521	3565	3608	3652	44
128	3696	3739	3782	3826	3869	3912	3955	3998	4040	4083	43
129	4126	4168	4210	4253	4295	4337	4379	4421	4462	4504	42
130	160·4546	4587	4629	4670	4712	4753	4794	4835	4876	4917	41
131	4958	4999	5039	5080	5120	5161	5201	5241	5282	5322	40
132	5362	5402	5442	5481	5521	5561	5600	5639	5679	5718	40
133	160·5757	5796	5835	5874	5913	5952	5991	6029	6067	6106	39
134	6145	6183	6222	6260	6299	6337	6375	6413	6450	6488	38
135	6526	6564	6601	6639	6676	6714	6751	6788	6826	6863	37
136	160·6900	6937	6974	7011	7048	7085	7122	7158	7195	7231	37
137	7268	7304	7340	7377	7413	7449	7485	7521	7557	7593	36
138	7629	7665	7700	7736	7771	7807	7842	7878	7913	7949	36
139	160·7984	8019	8054	8089	8124	8159	8194	8229	8263	8298	35
140	8333	8368	8402	8437	8471	8506	8540	8574	8609	8643	34
141	8677	8711	8745	8778	8812	8846	8880	8914	8947	8981	34
142	160·9015	9048	9082	9115	9149	9182	9215	9248	9282	9315	33
143	9348	9381	9414	9447	9480	9513	9546	9578	9611	9643	33
144	9676	9709	9741	9774	9806	9839	9871	9904	9936	9968	32
145	161·0000	0032	0064	0096	0128	0160	0192	0224	0255	0287	32
146	0319	0351	0382	0414	0445	0477	0508	0540	0571	0603	32
147	0634	0665	0696	0728	0759	0790	0821	0852	0882	0913	31
148	161·0944	0975	1006	1036	1067	1098	1129	1159	1190	1220	31
149	1251	1281	1312	1342	1373	1403	1433	1463	1494	1524	30
150	1554	1584	1614	1644	1674	1704	1734	1764	1793	1823	30
151	161·1853	1883	1913	1942	1972	2002	2031	2061	2090	2120	30
152	2149	2178	2208	2237	2267	2296	2325	2354	2384	2413	29
153	2442	2471	2500	2529	2558	2587	2616	2645	2673	2702	29

XXVI. T_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
154	161·2731	2760	2788	2817	2845	2874	2902	2931	2959	2988	29
155	3016	3044	3073	3101	3130	3158	3186	3214	3243	3271	28
156	3299	3327	3355	3383	3411	3439	3467	3495	3523	3551	28
157	161·3579	3607	3635	3662	3690	3718	3746	3773	3801	3828	28
158	3856	3883	3911	3938	3966	3993	4020	4047	4075	4102	27
159	4129	4156	4183	4211	4238	4265	4292	4319	4346	4373	27
160	161·4400	4427	4454	4481	4508	4535	4562	4588	4615	4641	27
161	4668	4695	4721	4748	4774	4801	4827	4854	4880	4907	27
162	4933	4959	4986	5012	5039	5065	5091	5117	5144	5170	26
163	161·5196	5222	5248	5275	5301	5327	5353	5379	5404	5430	26
164	5456	5482	5508	5533	5559	5585	5611	5636	5662	5687	26
165	5713	5739	5764	5790	5815	5841	5866	5892	5917	5943	26
166	161·5968	5993	6018	6044	6069	6094	6119	6144	6170	6195	25
167	6220	6245	6270	6295	6320	6345	6370	6395	6420	6445	25
168	6470	6495	6520	6544	6569	6594	6619	6643	6668	6692	25
169	161·6717	6742	6766	6791	6815	6840	6864	6889	6913	6938	25
170	6962	6986	7010	7035	7059	7083	7107	7131	7156	7180	24
171	7204	7228	7252	7277	7301	7325	7349	7373	7397	7421	24
172	161·7445	7469	7493	7516	7540	7564	7588	7612	7635	7659	24
173	7683	7707	7730	7754	7777	7801	7825	7848	7872	7895	24
174	7919	7942	7966	7989	8013	8036	8059	8082	8106	8129	23
175	161·8152	8175	8198	8222	8245	8268	8291	8314	8338	8361	23
176	8384	8407	8430	8453	8476	8499	8522	8545	8567	8590	23
177	8613	8636	8658	8681	8703	8726	8749	8771	8794	8816	23
178	161·8839	8862	8884	8907	8929	8952	8974	8997	9019	9042	23
179	9064	9086	9108	9131	9153	9175	9197	9219	9242	9264	22
180	9286	9308	9330	9353	9375	9397	9419	9441	9463	9485	22
181	161·9507	9529	9551	9572	9594	9616	9638	9660	9681	9703	22
182	9725	9747	9769	9790	9812	9834	9856	9877	9899	9920	22
183	9942	9964	9985	*0007	*0028	*0050	*0071	*0093	*0114	*0136	22
184	162·0157	0178	0199	0221	0242	0263	0284	0305	0327	0348	21
185	0369	0390	0411	0432	0453	0474	0495	0516	0537	0558	21
186	0579	0600	0621	0642	0663	0684	0705	0726	0746	0767	21
187	162·0788	0809	0829	0850	0870	0891	0912	0932	0953	0973	21
188	0994	1014	1035	1055	1076	1096	1116	1137	1157	1178	20
189	1198	1218	1239	1259	1280	1300	1320	1340	1361	1381	20
190	162·1401	1421	1441	1461	1481	1501	1521	1541	1562	1582	20
191	1602	1622	1642	1662	1682	1702	1722	1742	1761	1781	20
192	1801	1821	1841	1860	1880	1900	1920	1940	1959	1979	20
193	162·1999	2019	2038	2058	2077	2097	2116	2136	2155	2175	20
194	2194	2213	2233	2252	2272	2291	2310	2330	2349	2369	19
195	2388	2407	2426	2446	2465	2484	2503	2522	2542	2561	19
196	162·2580	2599	2618	2637	2656	2675	2694	2713	2731	2750	19
197	2769	2788	2807	2825	2844	2863	2882	2901	2919	2938	19
198	2957	2976	2994	3013	3031	3050	3069	3087	3106	3124	19
199	162·3143	3161	3180	3198	3217	3235	3253	3271	3290	3308	18
200	3326	3344	3362	3381	3399	3417	3435	3453	3472	3490	18
201	3508	3526	3544	3562	3580	3598	3616	3634	3651	3669	18

XXVI. T_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
202	162·3687	3705	3723	3740	3758	3776	3794	3811	3829	3846	18
203	3864	3882	3899	3917	3934	3952	3969	3987	4004	4022	18
204	4039	4056	4074	4091	4109	4126	4143	4160	4178	4195	17
205	162·4212	4229	4246	4264	4281	4298	4315	4332	4349	4366	17
206	4383	4400	4417	4434	4451	4468	4485	4502	4518	4535	17
207	4552	4569	4586	4602	4619	4636	4653	4669	4686	4702	17
208	162·4719	4735	4752	4768	4785	4801	4817	4834	4850	4867	16
209	4883	4899	4915	4932	4948	4964	4980	4996	5013	5029	16
210	5045	5061	5077	5093	5109	5125	5141	5157	5173	5189	16
211	162·5205	5221	5237	5252	5268	5284	5300	5316	5331	5347	16
212	5363	5379	5394	5410	5425	5441	5457	5472	5488	5503	16
213	5519	5535	5550	5566	5581	5597	5612	5628	5643	5659	16
214	162·5674	5689	5704	5720	5735	5750	5765	5780	5796	5811	15
215	5826	5841	5856	5871	5886	5901	5916	5931	5946	5961	15
216	5976	5991	6006	6021	6036	6051	6066	6081	6095	6110	15
217	162·6125	6140	6154	6169	6183	6198	6213	6227	6242	6256	15
218	6271	6286	6300	6315	6329	6344	6359	6373	6388	6402	15
219	6417	6431	6446	6460	6475	6489	6503	6517	6532	6546	14
220	162·6560	6574	6588	6603	6617	6631	6645	6659	6674	6688	14
221	6702	6716	6730	6745	6759	6773	6787	6801	6815	6829	14
222	6843	6857	6871	6885	6899	6913	6927	6941	6954	6968	14
223	162·6982	6996	7010	7023	7037	7051	7065	7079	7092	7106	14
224	7120	7134	7147	7161	7174	7188	7202	7215	7229	7242	14
225	7256	7270	7283	7297	7310	7324	7338	7351	7365	7378	14
226	162·7392	7405	7419	7432	7446	7459	7472	7486	7499	7513	13
227	7526	7539	7553	7566	7580	7593	7606	7620	7633	7647	13
228	7660	7673	7687	7700	7714	7727	7740	7753	7767	7780	13
229	162·7793	7806	7819	7833	7846	7859	7872	7886	7899	7913	13
230	7926	7939	7952	7966	7979	7992	8005	8018	8032	8045	13
231	8058	8071	8084	8097	8110	8123	8136	8149	8162	8175	13
232	162·8188	8201	8214	8228	8241	8254	8267	8280	8293	8306	13
233	8319	8332	8345	8358	8371	8384	8397	8410	8423	8436	13
234	8449	8462	8475	8488	8501	8514	8527	8540	8553	8566	13
235	162·8579	8592	8605	8617	8630	8643	8656	8669	8682	8695	13
236	8708	8721	8734	8746	8759	8772	8785	8798	8810	8823	13
237	8836	8849	8862	8874	8887	8900	8913	8926	8938	8951	13
238	162·8964	8977	8990	9002	9015	9028	9041	9054	9066	9079	13
239	9092	9105	9117	9130	9142	9155	9168	9181	9193	9206	13
240	9219	9232	9244	9257	9269	9282	9295	9308	9320	9333	13
241	162·9346	9359	9371	9384	9396	9409	9422	9434	9447	9459	13
242	9472	9485	9497	9510	9522	9535	9548	9560	9573	9585	13
243	9598	9610	9623	9635	9648	9660	9673	9685	9698	9710	12
244	162·9723	9735	9748	9760	9773	9785	9797	9810	9822	9835	12
245	9847	9859	9872	9884	9897	9909	9921	9934	9946	9959	12
246	9971	9983	9996	*0008	*0021	*0033	*0045	*0058	*0070	*0083	12
247	163·0095	0107	0119	0132	0144	0156	0168	0180	0193	0205	12
248	0217	0229	0241	0254	0266	0278	0290	0302	0315	0327	12
249	0339	0351	0363	0376	0388	0400	0412	0424	0437	0449	12

XXVI. T_v for Ogival-headed Projectiles (*continued*).

v	0	1	2	3	4	5	6	7	8	9	Diff.
f. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
250	163·0461	0473	0485	0497	0509	·0521	0533	0545	0557	0569	12
251	0581	0593	0605	0617	0629	0641	0653	0665	0677	0689	12
252	0701	0713	0725	0736	0748	0760	0772	0784	0795	0807	12
253	163·0819	0831	0843	0854	0866	0878	0890	0902	0913	0925	12
254	0937	0949	0960	0972	0983	0995	1007	1018	1030	1041	12
255	1053	1065	1076	1088	1099	1111	1123	1134	1146	1157	12
256	163·1169	1180	1192	1203	1215	1226	1237	1249	1260	1272	11
257	1283	1294	1305	1317	1328	1339	1350	1362	1373	1385	11
258	1396	1407	1418	1430	1441	1452	1463	1474	1486	1497	11
259	163·1508	1519	1530	1542	1553	1564	1575	1586	1597	1608	11
260	1619	1630	1641	1652	1663	1674	1685	1696	1707	1718	11
261	1729	1740	1751	1762	1773	1784	1795	1806	1816	1827	11
262	163·1838	1849	1860	1870	1881	1892	1903	1914	1924	1935	11
263	1946	1957	1967	1978	1988	1999	2010	2020	2031	2041	11
264	2052	2062	2073	2083	2094	2104	2115	2125	2136	2146	10
265	163·2157	2167	2178	2188	2199	2209	2219	2230	2240	2251	10
266	2261	2271	2281	2292	2302	2312	2322	2332	2343	2353	10
267	2363	2373	2383	2394	2404	2414	2424	2434	2445	2455	10
268	163·2465	2475	2485	2496	2506	2516	2526	2536	2546	2556	10
269	2566	2576	2586	2596	2606	2616	2626	2636	2646	2656	10
270	2666	2676	2686	2695	2705	2715	2725	2735	2744	2754	10
271	163·2764	2774	2784	2793	2803	2813	2823	2833	2842	2852	10
272	2862	2872	2881	2891	2900	2910	2920	2929	2939	2948	10
273	2958	2968	2977	2987	2996	3006	3016	3025	3035	3044	10
274	163·3054	3063	3073	3082	3092	3101	3110	3120	3129	3139	9
275	3148	3157	3167	3176	3186	3195	3204	3214	3223	3233	9
276	3242	3251	3260	3270	3279	3288	3297	3306	3316	3325	9
277	163·3334	3343	3352	3362	3371	3380	3389	3398	3407	3416	9
278	3425	3434	3443	3452	3461	3470	3479	3488	3497	3506	9
279	3515	3524	3533	3542	3551	3560	3569	3578	3587	3596	9
280	163·3605	3614	3623	3631	3640	3649	3658	3667	3675	3684	9
281	3693	3702	3711	3719	3728	3737	3746	3755	3763	3772	9
282	3781	3790	3798	3807	3815	3824	3833	3842	3850	3859	9
283	163·3868	3877	3885	3894	3902	3911	3920	3928	3937	3945	9
284	3954	3962	3971	3979	3988	3996	4004	4013	4021	4030	8
285	4038	4046	4055	4063	4072	4080	4088	4097	4105	4114	8
286	163·4122	4130	4139	4147	4156	4164	4172	4180	4189	4197	8
287	4205	4213	4221	4230	4238	4246	4254	4262	4271	4279	8
288	4287	4295	4303	4312	4320	4328	4336	4344	4353	4361	8
289	163·4369	4377	4385	4393	4401	4409	4417	4425	4433	4441	8
290	4449	4457	4465	4473	4481	4489	4497	4505	4513	4521	8

XXVII. Values of $\frac{\mathfrak{k}}{g}$ for the Newtonian Law, and of $\frac{\mathfrak{K}}{g}$ for the Cubic Law of the Resistance of the Air to Spherical and Ogival-headed Projectiles ($\Pi = 1·206$ kil.; or $\omega = 527$ grains; $g = 9·809$ m. s.).

	Spherical Projectiles.		Ogival-headed Projectiles.			Spherical Projectiles.		Ogival-headed Projectiles.	
$\mathfrak{v}$	Newtonian Law $\frac{\mathfrak{k}}{g}$	Cubic Law $\frac{\mathfrak{K}}{g}$	Newtonian Law $\frac{\mathfrak{k}}{g}$	Cubic Law $\frac{\mathfrak{K}}{g}$	$\mathfrak{v}$	Newtonian Law $\frac{\mathfrak{k}}{g}$	Cubic Law $\frac{\mathfrak{K}}{g}$	Newtonian Law $\frac{\mathfrak{k}}{g}$	Cubic Law $\frac{\mathfrak{K}}{g}$
m. s.					*m. s.*				
50			1·40	28·10	450	4·69	10·42	3·43	7·62
60			1·40	23·41	460	4·71	10·25	3·42	7·44
70			1·40	20·07	470	4·73	10·07	3·40	7·24
80			1·40	17·55	480	4·75	9·90	3·38	7·04
90			1·40	15·60	490	4·76	9·72	3·36	6·85
100			1·40	14·03	500	4·77	9·55	3·34	6·67
110			1·40	12·76	510	4·78	9·37	3·31	6·50
120			1·40	11·69	520	4·78	9·19	3·29	6·32
130			1·40	10·79	530	4·78	9·02	3·27	6·16
140			1·40	10·02	540	4·78	8·85	3·25	6·02
150			1·40	9·36	550	4·78	8·68	3·23	5·87
160			1·40	8·77	560	4·78	8·53	3·21	5·73
170			1·40	8·25	570	4·78	8·39	3·20	5·60
180			1·40	7·79	580	4·80	8·28	3·19	5·48
190			1·40	7·39	590	4·83	8·18	3·18	5·38
200			1·40	7·02	600	4·85	8·08	3·17	5·28
210			1·40	6·68	610	4·87	7·98	3·18	5·21
220			1·40	6·38	620	4·88	7·87	3·20	5·16
230			1·40	6·10	630	4·88	7·74	3·23	5·13
240			1·40	5·85	640	4·87	7·60	3·26	5·10
250	2·68	10·72	1·41	5·62	650	4·85	7·46	3·30	5·07
260	2·79	10·72	1·46	5·60	660	4·83	7·32	3·33	5·05
270	2·89	10·72	1·51	5·60	670	4·82	7·19	3·36	5·01
280	3·00	10·72	1·57	5·60	680	4·80	7·07	3·37	4·95
290	3·11	10·72	1·62	5·60	690	4·79	6·94	3·35	4·86
300	3·23	10·75	1·68	5·60	700	4·78	6·82	3·32	4·75
310	3·39	10·93	1·75	5·66	710			3·28	4·62
320	3·63	10·35	2·12	6·64	720			3·23	4·49
330	3·84	11·63	2·59	7·83	730			3·18	4·36
340	4·01	11·79	2·79	8·21	740			3·14	4·24
350	4·15	11·86	2·91	8·34	750			3·10	4·13
360	4·27	11·87	3·00	8·34	760			3·07	4·04
370	4·36	11·79	3·09	8·34	770			3·07	3·99
380	4·42	11·64	3·17	8·34	780			3·08	3·95
390	4·47	11·45	3·25	8·34	790			3·10	3·92
400	4·50	11·24	3·32	8·30	800			3·13	3·91
410	4·54	11·08	3·37	8·21	810			3·17	3·91
420	4·59	10·92	3·40	8·10	820			3·20	3·91
430	4·63	10·76	3·42	7·96	830			3·24	3·90
440	4·66	10·59	3·43	7·80	840			3·28	3·90

Approximate Laws of the Resistance of the Air to the Motion of Projectiles (*French Measures*).

$\Pi = 1\cdot206$ kil.; $\omega = 527$ grains; $g = 9\cdot809$ m. s.

XXVIII. Spherical Projectiles.

$v > 396$ m. s.,	$\rho \propto v^2$,	$\frac{k}{g} = 4\cdot761$,	$\log \frac{k}{g} = 0\cdot67774$,
$v < 396 > 335$ m. s.,	$\rho \propto v^3$,	$\frac{K}{g} = 11\cdot703$,	$\log \frac{K}{g} = 1\cdot06830$,
$v < 335 > 305$ m. s.,	$\rho \propto v^4$,	$\frac{h}{g} = 35\cdot350$,	$\log \frac{h}{g} = 1\cdot54839$,
$v < 305 > 256$ m. s.,	$\rho \propto v^3$,	$\frac{K}{g} = 10\cdot706$,	$\log \frac{K}{g} = 1\cdot02963$,
$v < 256$ m. s. ,	$\rho \propto v^2$,	$\frac{k}{g} = 2\cdot744$,	$\log \frac{k}{g} = 0\cdot43833$.

XXIX. Ogival-headed Projectiles.

$v > 396$ m. s.,	$\rho \propto v^2$,	$\frac{k}{g} = 3\cdot275$,	$\log \frac{k}{g} = 0\cdot51518$,
$v < 396 > 335$ m. s.,	$\rho \propto v^3$,	$\frac{K}{g} = 8\cdot302$,	$\log \frac{K}{g} = 0\cdot91916$,
$v < 335 > 305$ m. s.,	$\rho \propto v^6$,	$\frac{L}{g} = 206\cdot92$,	$\log \frac{L}{g} = 2\cdot31580$,
$v < 305 > 250$ m. s.,	$\rho \propto v^3$,	$\frac{K}{g} = 5\cdot600$,	$\log \frac{K}{g} = 0\cdot74822$,
$v < 250$ m. s. ,	$\rho \propto v^2$,	$\frac{k}{g} = 1\cdot403$,	$\log \frac{k}{g} = 0\cdot14710$.

XXX. $\mathfrak{S}_{v}$ for Spherical Projectiles (II = 1·206 kil. or ω = 527 grains).

v	0	1	2	3	4	5	6	7	8	9	Diff.
m. s.	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	+
12	68	376	682	986	1288	1586	1881	2175	2466	2755	299
13	3042	3327	3610	3891	4170	4447	4721	4993	5263	5531	277
14	5798	6062	6325	6586	6845	7102	7358	7612	7864	8114	257
15	8363	8610	8856	9100	9342	9582	9821	*0058	*0294	*0528	241
16	1 0761	0993	1223	1452	1680	1906	2131	2355	2577	2799	226
17	3018	3237	3454	3670	3884	4097	4309	4519	4728	4936	213
18	5142	5348	5552	5755	5957	6158	6357	6556	6753	6951	201
19	7149	7343	7537	7730	7922	8113	8304	8494	8683	8871	191
20	9059	9245	9430	9613	9795	9976	*0156	*0336	*0514	*0692	182
21	2 0868	1044	1219	1393	1567	1740	1913	2085	2257	2427	173
22	2597	2766	2934	3101	3267	3433	3598	3762	3926	4088	166
23	4250	4411	4571	4731	4890	5048	5206	5363	5519	5675	158
24	5830	5985	6139	6293	6446	6598	6750	6900	7050	7199	152
25	7348	7497	7645	7792	7939	8085	8231	8376	8521	8665	146
26	2 8808	8948	9087	9224	9361	9496	9631	9764	9897	*0029	136
27	3 0161	0291	0420	0547	0674	0799	0926	1049	1171	1293	126
28	1414	1535	1655	1774	1893	2011	2128	2244	2359	2473	118
29	2587	2700	2812	2923	3034	3144	3253	3361	3469	3576	110
30	3682	3787	3892	3995	4098	4200	4301	4401	4500	4598	102
31	3 4695	4791	4887	4982	5076	5168	5260	5350	5439	5528	93
32	5616	5703	5790	5876	5961	6046	6131	6215	6298	6377	85
33	6456	6536	6615	6694	6772	6850	6927	7004	7080	7155	78
34	7230	7305	7379	7453	7526	7599	7671	7743	7814	7885	73
35	7955	8025	8094	8163	8232	8300	8368	8436	8503	8570	68
36	3 8636	8702	8768	8834	8899	8964	9028	9092	9156	9220	65
37	9283	9347	9410	9473	9535	9598	9660	9722	9784	9845	62
38	9906	9966	*0026	*0086	*0145	*0204	*0263	*0323	*0382	*0441	59
39	4 0500	0559	0617	0675	0733	0791	0848	0905	0962	1019	58
40	1076	1133	1190	1246	1302	1358	1413	1468	1523	1578	56
41	4 1632	1686	1740	1794	1848	1902	1955	2009	2063	2117	54
42	2171	2224	2277	2330	2382	2434	2485	2537	2588	2640	52
43	2691	2743	2794	2845	2896	2947	2997	3047	3096	3146	51
44	3195	3245	3294	3344	3393	3443	3492	3542	3591	3640	49
45	3688	3736	3784	3832	3879	3926	3973	4021	4068	4115	47
46	4 4162	4210	4257	4304	4351	4398	4444	4490	4536	4582	46
47	4628	4674	4719	4764	4809	4854	4899	4944	4989	5034	45
48	5079	5124	5169	5214	5258	5302	5346	5390	5434	5478	44
49	5521	5565	5609	5653	5696	5739	5782	5825	5868	5911	43
50	5954	5997	6039	6082	6125	6168	6210	6252	6294	6336	42
51	4 6378	6420	6462	6504	6545	6586	6627	6668	6708	6749	41
52	6789	6830	6870	6911	6952	6993	7033	7074	7114	7155	41
53	7195	7236	7276	7316	7356	7396	7436	7476	7516	7556	40
54	7595	7635	7674	7713	7752	7792	7831	7870	7909	7948	39
55	7987	8026	8064	8103	8141	8180	8218	8257	8295	8333	38
56	4 8371	8409	8447	8485	8523	8561	8599	8637	8674	8712	38
57	8749	8786	8823	8861	8898	8935	8972	9009	9046	9083	37
58	9119	9156	9192	9229	9265	9301	9337	9373	9409	9445	36
59	9481	9517	9552	9588	9623	9659	9694	9730	9765	9800	35
60	9835	9870	9905	9940	9975	*0010	*0045	*0080	*0114	*0148	35
61	5 0182	0217	0251	0285	0319	0353	0387	0421	0455	0489	34
62	0523	0557	0590	0624	0657	0690	0723	0757	0790	0823	33
63	0856	0889	0922	0955	0988	1021	1054	1087	1120	1153	33
64	1186	1219	1252	1285	1317	1350	1382	1415	1447	1479	33
65	1511	1544	1576	1608	1640	1673	1705	1737	1769	1801	32
66	5 1833	1865	1897	1929	1961	1993	2024	2056	2088	2120	32
67	2151	2183	2214	2246	2277	2309	2340	2371	2402	2434	31
68	2465	2496	2527	2558	2589	2620	2651	2682	2713	2744	31
69	2775	2806	2837	2868	2899	2930	2960	2991	3021	3052	31

XXXI. $\mathfrak{T}_b$ for Spherical Projectiles (II = 1·205 kil. or ω = 527 grains).

b	0	1	2	3	4	5	6	7	8	9	Diff.
m. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
12	55·9	58·5	61·1	63·6	66·1	68·5	70·8	73·1	75·4	77·6	2·4
13	79·8	82·0	84·2	86·4	88·5	90 6	92·6	94·6	96·6	98 5	2·1
14	100·4	102·3	104·1	105·9	107·7	109·5	111·2	113·0	114·7	116·4	1·8
15	118·0	119·7	121·3	122·9	124·5	126·1	127 6	129·1	130·6	132·1	1·6
16	133·5	135·0	136·4	137·8	139·2	140·6	142·0	143·4	144·7	146·0	1·4
17	147·2	148·5	149·7	151·0	152·2	153·4	154·6	155·8	156·9	158·1	1·2
18	159·2	160·4	161·5	162·6	163·7	164·9	166·0	167·1	168·2	169·2	1·1
19	170·2	171·2	172·2	173·2	174·2	175·2	176·2	177·1	178·1	179·0	1·0
20	180·0	180·9	181·8	182·7	183·6	184·5	185·4	186·3	187·1	188·0	0·9
21	1 88·83	89·66	90·49	91·31	92·13	92·94	93·75	94·54	95·33	96·10	·81
22	96·87	97·63	98·39	99·14	99·88	*00·62	*01·35	*02·08	*02 81	*03·52	·74
23	2 04·23	04·92	05·61	06·29	06·97	07·65	08·32	08·99	09·65	10·31	·68
24	10·96	11·61	12·25	12·88	13·51	14·13	14·75	15·36	15·96	16·56	·62
25	17·15	17·74	18·33	18·91	19·49	20·07	20·64	21·21	21·77	22·31	·57
26	2 22·84	23·38	23·92	24·45	24·97	25·48	25·99	26·49	26·99	27·48	·52
27	27·96	28·44	28·91	29·38	29·85	30·31	30·77	31·22	31·67	32·11	·46
28	32·55	32·98	33·40	33·82	34·24	34·65	35·06	35·46	35·86	36·26	·41
29	36·65	37·04	37·43	37·81	38·19	38·56	38·93	39·29	39·65	40·01	·37
30	40·36	40·71	41·05	41·39	41·73	42·07	42·41	42·74	43·06	43·37	·33
31	2 43·68	43·99	44·29	44·60	44·90	45·20	45·49	45·78	46·06	46·34	·30
32	46·62	46·89	47·15	47·42	47·68	47·94	48·20	48·46	48·71	48·96	·26
33	49·20	49·44	49·68	49·92	50·15	50·38	50·61	50·84	51·07	51·29	·23
34	51·51	51·73	51·95	52·17	52·38	52·59	52·80	53·01	53·21	53·41	·21
35	53·61	53·81	54·01	54·21	54·40	54·60	54·79	54·98	55·17	55·36	·19
36	2 55·54	55·72	55·90	56·08	56·26	56·44	56·61	56·79	56·96	57·13	·18
37	57·30	57·47	57·64	57·81	57·98	58·15	58·31	58·48	58·64	58·80	·17
38	58·96	59·12	59·28	59·44	59·59	59·75	59·90	60·05	60·20	60·35	·15
39	60·50	60·65	60·80	60·95	61·10	61·25	61·39	61·53	61·67	61·82	·15
40	61·96	62·10	62·24	62·38	62·52	62·66	62·80	62·94	63·07	63·21	·14
41	2 63·34	63·48	63·61	63·74	63·87	64·00	64·12	64·25	64·38	64·51	·13
42	64·63	64·76	64·88	65·01	65·13	65·26	65·38	65·50	65·62	65·74	·12
43	65·86	65·98	66·10	66·22	66·33	66·45	66·56	66·68	66·79	66·91	·12
44	67·02	67·14	67·25	67·36	67·47	67·58	67·69	67·80	67·91	68·02	·11
45	68·13	68·24	68·34	68·45	68·55	68·66	68·76	68·87	68·97	69·07	·10
46	2 69·17	69·28	69·38	69·48	69·58	69·68	69·78	69·88	69·98	70·08	·10
47	70·17	70·27	70·36	70·46	70·56	70·65	70·75	70·84	70·94	71·03	·10
48	27 1·123	1·216	1·308	1·400	1·492	1·583	1·674	1·765	1·855	1·945	·092
49	2·034	2·123	2·211	2·299	2·387	2·474	2·561	2·648	2·734	2·820	·087
50	2·905	2·990	3·075	3·160	3·244	3·328	3·411	3·495	3·578	3·661	·084
51	27 3·743	3·825	3·907	3·988	4·069	4·150	4·230	4·310	4·389	4·468	·081
52	4·547	4·625	4·703	4·781	4·859	4·936	5·013	5·090	5·167	5·243	·077
53	5·319	5·395	5·471	5·546	5·621	5·696	5·770	5·844	5·917	5 991	·075
54	6·064	6·137	6·209	6·282	6·354	6·426	6·498	6·570	6·640	6·712	·072
55	6·783	6·854	6·924	6·994	7·063	7·133	7·202	7·271	7·340	7·409	·070
56	27 7·477	7·545	7·613	7·681	7·748	7·815	7·882	7·948	8·014	8·080	·067
57	8·145	8·210	8·275	8·340	8·405	8·471	8·534	8·598	8·662	8·726	·065
58	8·789	8·852	8·915	8·978	9·040	9·102	9·163	9·225	9·286	9·347	·062
59	9·408	9·469	9·529	9·589	9·648	9·708	9·767	9·826	9·885	9·944	·060
60	28 0·003	0·061	0·119	0·177	0·234	0·292	0·349	0·406	0·463	0·520	·058
61	28 0·577	0·633	0·689	0·745	0·800	0·855	0·910	0·965	1·020	1·075	·055
62	1·129	1·184	1·238	1·292	1·346	1·400	1·453	1·506	1·559	1·612	·054
63	1·665	1·718	1·770	1·822	1·874	1·926	1·977	2·029	2·080	2·132	·052
64	2·183	2·234	2·285	2·336	2·386	2·437	2·487	2·537	2·587	2·637	·050
65	2·687	2·737	2·786	2·836	2·885	2·934	2·983	3·032	3·081	3·130	·049
66	28 3·178	3·226	3·274	3·322	3·370	3·418	3·466	3·514	3·561	3·609	·048
67	3·656	3·704	3·751	3·798	3·845	3·892	3·938	3·984	4·030	4·076	·047
68	4·122	4·168	4·213	4·259	4·304	4·349	4·394	4·439	4·484	4·529	·045
69	4·574	4·619	4·663	4·708	4·752	4·796	4·840	4·884	4·928	4·972	·044

XXXII. $\mathfrak{S}_v$ for Ogival-headed Projectiles (II = 1·206 kil., or $\omega = 527$ grains).

v	0	1	2	3	4	5	6	7	8	9	Diff.
m. s.	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	+
5	4 0083	1516	2923	4307	5666	7002	8312	9596	*0857	*2101	1335
6	5 3323	4524	5706	6871	8018	9148	*0260	*1355	*2432	*3491	1130
7	6 4529	5558	6573	7575	8564	9536	*0499	*1448	*2385	*3312	966
8	7 4226	5128	6020	6899	7770	8631	9484	*0328	*1159	*1977	851
9	8 2785	3586	4381	5168	5946	6715	7476	8228	8975	9714	770
10	9 0443	1169	1885	2593	3292	3986	4677	5358	6035	6703	696
11	9 7363	8022	8673	9319	9961	*0594	*1222	*1847	*2466	*3077	635
12	10 3688	4291	4889	5482	6071	6651	7232	7808	8379	8946	584
13	10 9504	*0058	*0612	*1162	*1707	*2243	*2779	*3311	*3843	*4366	540
14	11 4889	5403	5918	6424	6929	7430	7931	8428	8921	9409	502
15	11 9897	*0384	*0864	*1338	*1809	*2279	*2745	*3211	*3673	*4130	470
16	12 4587	5040	5488	5937	6381	6825	7264	7699	8135	8565	442
17	12 8996	9423	9845	*0267	*0689	*1102	*1515	*1928	*2337	*2742	416
18	13 3146	3550	3951	4351	4746	5142	5533	5924	6311	6694	394
19	13 7076	7459	7837	8215	8593	8966	9340	9709	*0079	*0443	374
20	14 0808	1169	1529	1890	2246	2602	2958	3310	3657	4004	355
21	14 4351	4694	5037	5380	5723	6061	6396	6734	7068	7398	339
22	14 7728	8057	8383	8712	9038	9358	9679	*0000	*0321	*0638	323
23	15 0959	1275	1592	1904	2212	2524	2831	3139	3442	3750	310
24	15 4053	4357	4660	4959	5254	5552	5847	6142	6436	6726	297
25	15 7016	7306	7597	7882	8168	8449	8726	9003	9276	9548	281
26	15 9821	*0089	*0357	*0621	*0880	*1140	*1399	*1654	*1909	*2160	260
27	16 2410	2661	2911	3156	3400	3644	3886	4124	4358	4591	242
28	16 4819	5052	5281	5509	5738	5962	6184	6406	6626	6846	225
29	16 7066	7281	7492	7707	7918	8129	8336	8543	8749	8956	210
30	16 9158	9360	9563	9760	9956	*0152	*0345	*0538	*0732	*0921	196
31	17 1110	1299	1484	1664	1840	2015	2187	2354	2521	2679	174
32	17 2833	2978	3123	3260	3396	3528	3655	3783	3906	4029	133
33	17 4148	4267	4384	4499	4613	4725	4836	4947	5057	5164	113
34	17 5271	5377	5482	5586	5690	5793	5895	5996	6098	6199	103
35	17 6299	6399	6498	6595	6693	6790	6888	6984	7079	7175	97
36	17 7269	7363	7457	7550	7642	7734	7825	7916	8007	8098	92
37	17 8188	8277	8365	8453	8540	8627	8714	8800	8886	8972	87
38	17 9057	9141	9225	9309	9392	9475	9557	9639	9721	9801	83
39	17 9882	9962	*0041	*0120	*0200	*0278	*0356	*0434	*0512	*0589	79
40	18 0666	0743	0819	0895	0971	1047	1122	1197	1271	1346	76
41	18 1419	1493	1566	1640	1713	1786	1858	1931	2003	2074	73
42	18 2146	2217	2288	2359	2429	2500	2570	2640	2710	2779	70
43	18 2849	2918	2987	3055	3124	3192	3260	3328	3396	3464	68
44	18 3532	3599	3666	3733	3800	3867	3934	4001	4067	4133	67
45	18 4199	4265	4331	4397	4463	4528	4593	4658	4723	4788	65

XXXII. $\mathfrak{S}_{\mathfrak{v}}$ for Ogival-headed Projectiles (*continued*).

$\mathfrak{v}$	0	1	2	3	4	5	6	7	8	9	Diff.
m. s.	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	Metres	+
46	18 4853	4918	4983	5048	5112	5176	5240	5304	5368	5432	64
47	5495	5559	5623	5687	5751	5815	5878	5941	6004	6067	64
48	6130	6193	6255	6318	6380	6443	6505	6568	6630	6692	62
49	6754	6816	6878	6940	7001	7063	7124	7185	7246	7308	62
50	7369	7430	7491	7552	7613	7674	7734	7795	7855	7916	61
51	18 7976	8037	8097	8157	8217	8277	8337	8397	8457	8517	60
52	8576	8636	8695	8755	8814	8874	8933	8992	9051	9110	59
53	9169	9228	9287	9346	9404	9463	9521	9580	9638	9697	59
54	9755	9813	9871	9929	9986	*0044	*0102	*0160	*0217	*0275	58
55	19 0332	0390	0447	0504	0561	0618	0675	0732	0789	0846	57
56	19 0903	0960	1016	1073	1129	1186	1242	1298	1354	1410	56
57	1466	1522	1578	1634	1689	1745	1800	1856	1911	1967	56
58	2022	2077	2132	2187	2242	2297	2352	2407	2462	2517	55
59	2571	2626	2680	2734	2788	2843	2897	2951	3005	3059	54
60	3113	3167	3220	3273	3326	3379	3432	3485	3538	3591	53
61	19 3643	3696	3748	3801	3853	3905	3957	4009	4061	4113	52
62	4164	4216	4267	4318	4369	4420	4470	4521	4571	4622	51
63	4672	4722	4772	4822	4872	4922	4971	5020	5069	5118	50
64	5167	5215	5264	5312	5361	5409	5458	5506	5554	5601	48
65	5648	5696	5743	5791	5838	5885	5932	5979	6026	6072	47
66	19 6119	6165	6211	6257	6303	6349	6395	6440	6486	6531	46
67	6576	6622	6667	6712	6757	6802	6847	6892	6937	6982	45
68	7026	7071	7115	7160	7204	7248	7292	7336	7380	7424	44
69	7468	7512	7555	7599	7643	7687	7731	7775	7819	7863	44
70	7907	7951	7995	8039	8082	8126	8170	8214	8257	8301	44
71	19 8345	8389	8432	8476	8520	8564	8607	8651	8695	8739	44
72	8782	8826	8870	8914	8958	9002	9046	9090	9134	9178	44
73	9222	9266	9309	9353	9397	9441	9485	9529	9573	9617	44
74	9661	9705	9749	9793	9836	9880	9924	9968	*0012	*0056	44
75	20 0100	0144	0188	0232	0275	0319	0363	0407	0451	0495	44
76	20 0539	0583	0626	0670	0713	0757	0800	0844	0887	0930	43
77	0973	1016	1059	1102	1145	1188	1230	1273	1315	1358	43
78	1400	1443	1485	1527	1569	1611	1653	1695	1737	1779	42
79	1820	1862	1904	1946	1987	2028	2069	2110	2151	2192	41
80	2233	2274	2314	2355	2395	2435	2475	2515	2555	2595	40
81	20 2635	2675	2714	2754	2793	2833	2872	2911	2950	2989	39
82	3028	3067	3105	3144	3182	3221	3259	3298	3336	3374	38
83	3412	3450	3487	3525	3563	3601	3638	3676	3713	3750	38
84	3787	3824	3861	3898	3935	3972	4008	4045	4081	4117	37
85	4153	4190	4226	4262	4298	4334	4369	4405	4440	4476	36
86	20 4511	4546	4581	4617	4652	4687	4722	4757	4792	4827	35
87	4861	4896	4930	4965	4999	5033	5067	5101	5135	5169	34
88	5203	5237	5270	5304	5337	5370	5404	5437	5470	5503	33

XXXIII. $\mathfrak{T}_v$ for Ogival-headed Projectiles
($\Pi = 1{\cdot}206$ kil. or $\omega = 527$ grains).

v	0	1	2	3	4	5	6	7	8	9	Diff.
m. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
5	1074	1102	1129	1156	1181	1206	1230	1252	1274	1296	24
6	1316	1336	1355	1374	1392	1409	1426	1443	1459	1474	18
7	1489	1504	1518	1532	1545	1558	1571	1584	1596	1608	13
8	1619	1630	1641	1652	1662	1672	1682	1692	1701	1711	10
9	1720	1729	1737	1746	1754	1762	1770	1778	1786	1793	8
10	1800	1808	1815	1822	1828	1835	1842	1848	1854	1860	7
11	1 866·6	872·7	878·5	884·1	889·6	895·1	900·5	906·0	911·4	916·5	5·5
12	921·7	926·6	931·4	936·3	941·1	945·7	950·3	954·9	959·4	963·8	4·7
13	968·1	972·4	976·7	980·8	984·8	988·8	992·8	996·7	*000·5	*004·3	4·0
14	2 008·1	011·7	015·3	018·9	022·4	025·9	029·3	032·7	036·1	039·4	3·5
15	042·6	045·9	049·1	052·2	055·2	058·2	061·2	064·2	067·1	070·0	3·0
16	2 072·9	075·7	078·5	081·3	084·0	086·7	089·3	091·9	094·5	097·1	2·7
17	099·6	102·1	104·6	107·0	109·4	111·8	114·1	116·5	118·8	121·1	2·4
18	123·4	125·6	127·8	130·0	132·1	134·2	136·3	138·4	140·5	142·6	2·1
19	144·6	146·6	148·6	150·6	152·5	154·4	156·3	158·2	160·0	161·9	1·9
20	163·7	165·5	167·3	169·1	170·8	172·6	174·3	176·0	177·7	179·4	1·7
21	2 181·0	182·6	184·2	185·8	187·4	189·0	190·6	192·2	193·7	195·2	1·6
22	196·7	198·2	199·6	201·1	202·5	204·0	205·4	206·8	208·2	209·6	1·4
23	211·0	212·4	213·8	215·2	216·5	217·8	219·1	220·4	221·7	223·0	1·3
24	224·3	225·6	226·8	228·1	229·3	230·5	231·7	232·9	234·1	235·3	1·2
25	236·4	237·6	238·7	239·8	240·9	242·0	243·1	244·2	245·2	246·3	1·1
26	22 47·33	48·36	49·38	50·39	51·38	52·36	53·34	54·30	55·25	56·20	·99
27	57·13	58·04	58·95	59·85	60·74	61·62	62·49	63·36	64·21	65·05	·88
28	65·88	66·71	67·53	68·33	69·13	69·92	70·70	71·47	72·24	73·00	·79
29	73·76	74·50	75·24	75·97	76·69	77·40	78·11	78·81	79·50	80·18	·71
30	80·85	81·52	82·19	82·84	83·49	84·14	84·78	85·41	86·03	86·65	·64
31	22 87·26	87·86	88·45	89·04	89·61	90·16	90·69	91·22	91·73	92·22	·55
32	92·71	93·18	93·63	94·07	94·50	94·90	95·29	95·67	96·04	96·42	·41
33	96·79	97·15	97·50	97·85	98·19	98·52	98·85	99·18	99·50	99·81	·34
34	23 00·12	00·43	00·74	01·05	01·35	01·65	01·95	02·24	02·53	02·82	·30
35	03·11	03·39	03·67	03·95	04·23	04·51	04·78	05·05	05·31	05·58	·27
36	23 05·84	06·10	06·36	06·62	06·87	07·13	07·38	07·63	07·87	08·12	·25
37	08·36	08·60	08·84	09·08	09·31	09·54	09·77	10·00	10·23	10·46	·23
38	10·68	10·90	11·12	11·34	11·56	11·78	11·99	12·20	12·41	12·62	·22
39	12·83	13·03	13·23	13·43	13·63	13·83	14·03	14·23	14·42	14·62	·20
40	14·81	15·00	15·19	15·38	15·57	15·75	15·94	16·12	16·30	16·49	·19
41	23 16·67	16·85	17·03	17·21	17·38	17·56	17·73	17·91	18·08	18·25	·18
42	18·42	18·59	18·76	18·93	19·09	19·26	19·42	19·59	19·75	19·92	·17
43	20·08	20·25	20·41	20·57	20·72	20·87	21·02	21·18	21·33	21·49	·16
44	21·64	21·80	21·95	22·10	22·25	22·40	22·55	22·70	22·85	23·00	·15
45	23·14	23·29	23·43	23·58	23·72	23·87	24·01	24·16	24·30	24·44	·14

XXXIII. $\mathfrak{T}_{\mathfrak{v}}$ for Ogival-headed Projectiles (*continued*).

$\mathfrak{v}$	0	1	2	3	4	5	6	7	8	9	Diff.
m. s.	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	Seconds	+
46	23 24·58	24·72	24·86	25·00	25·14	25·28	25·42	25·56	25·69	25·83	·14
47	25·96	26·10	26·23	26·37	26·50	26·64	26·77	26·90	27·03	27·17	·13
48	27·30	27·43	27·56	27·69	27·82	27·95	28·07	28·20	28·33	28·46	·13
49	28·58	28·71	28·84	28·97	29·09	29·22	29·34	29·46	29·58	29·71	·13
50	29·83	29·95	30·07	30·19	30·31	30·43	30·55	30·67	30·79	30·91	·12
51	23 31·03	31·15	31·27	31·39	31·50	31·62	31·74	31·86	31·97	32·09	·12
52	32·20	32·31	32·42	32·54	32·65	32·77	32·88	32·99	33·10	33·21	·11
53	33·32	33·44	33·55	33·66	33·77	33·88	33·99	34·10	34·20	34·31	·11
54	34·42	34·53	34·63	34·74	34·85	34·95	35·06	35·16	35·27	35·37	·11
55	35·48	35·58	35·69	35·79	35·89	36·00	36·10	36·20	36·30	36·41	·10
56	233 6·508	6·609	6·709	6·809	6·909	7·009	7·109	7·208	7·307	7·405	·100
57	7·503	7·601	7·698	7·796	7·893	7·990	8·086	8·182	8·277	8·373	·097
58	8·468	8·564	8·659	8·754	8·849	8·943	9·036	9·129	9·222	9·315	·094
59	9·408	9·501	9·593	9·685	9·776	9·867	9·958	*0·048	*0·138	*0·228	·091
60	234 0·317	0·407	0·496	0·585	0·673	0·761	0·849	0·937	1·024	1·110	·088
61	234 1·195	1·282	1·368	1·454	1·539	1·624	1·708	1·792	1·876	1·959	·085
62	2·042	2·125	2·207	2·289	2·371	2·453	2·534	2·615	2·695	2·775	·081
63	2·855	2·935	3·014	3·093	3·171	3·249	3·327	3·405	3·482	3·559	·078
64	3·635	3·711	3·786	3·862	3·937	4·012	4·086	4·161	4·235	4·309	·075
65	4·382	4·455	4·528	4·601	4·673	4·745	4·816	4·887	4·958	5·028	·072
66	234 5·098	5·168	5·238	5·308	5·377	5·446	5·515	5·584	5·652	5·720	·069
67	5·788	5·856	5·923	5·990	6·057	6·124	6·190	6·256	6·322	6·388	·067
68	6·454	6·519	6·584	6·649	6·713	6·778	6·842	6·906	6·970	7·034	·065
69	7·098	7·162	7·225	7·289	7·352	7·416	7·479	7·542	7·605	7·668	·063
70	7·730	7·793	7·855	7·917	7·979	8·041	8·103	8·165	8·227	8·289	·062
71	234 8·351	8·413	8·474	8·536	8·598	8·660	8·721	8·782	8·843	8·904	·062
72	8·965	9·026	9·086	9·147	9·207	9·268	9·328	9·389	9·449	9·510	·061
73	9·570	9·630	9·690	9·750	9·810	9·870	9·929	9·989	*0·048	*0·108	·060
74	235 0·167	0·227	0·286	0·345	0·404	0·463	0·522	0·581	0·639	0·698	·059
75	0·756	0·815	0·873	0·932	0·990	1·048	1·106	1·164	1·222	1·280	·058
76	235 1·337	1·394	1·451	1·508	1·565	1·622	1·679	1·736	1·792	1·849	·057
77	1·905	1·961	2·016	2·072	2·127	2·182	2·237	2·292	2·347	2·402	·055
78	2·456	2·510	2·564	2·618	2·672	2·726	2·779	2·832	2·885	2·938	·054
79	2·991	3·044	3·096	3·148	3·200	3·252	3·304	3·356	3·408	3·459	·052
80	3·510	3·561	3·612	3·662	3·712	3·762	3·812	3·862	3·911	3·960	·050
81	235 4·009	4·058	4·107	4·156	4·204	4·253	4·301	4·349	4·397	4·444	·048
82	4·491	4·539	4·586	4·633	4·680	4·727	4·773	4·820	4·866	4·912	·047
83	4·958	5·004	5·049	5·094	5·139	5·184	5·229	5·274	5·318	5·363	·045
84	5·407	5·451	5·495	5·539	5·582	5·625	5·668	5·711	5·754	5·797	·043
85	5·839	5·882	5·924	5·966	6·008	6·050	6·092	6·134	6·176	6·218	·042
86	235 6·259	6·300	6·341	6·382	6·422	6·463	6·503	6·544	6·584	6·624	·041
87	6·663	6·703	6·742	6·782	6·821	6·860	6·899	6·938	6·976	7·015	·039
88	7·053	7·091	7·129	7·167	7·205	7·243	7·281	7·319	7·356	7·393	·038

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